CO2

MANUAL

31E08024

CO2 TRANSCRITICAL

eCO_2Boost™

INSTALLATION AND OPERATION ***MANUAL***

KYSOR WARREN

CO2 MANUAL

1

CO2 TRANSCRITICAL BOOSTER **SYSTEM**

KYSOR WARREN

CO2 TRANSCRITICAL BOOSTER SYSTEM

This manual provides information for system warranty, inspection installation, start-up, operation, service and maintenance of Kysor Warren Epta US CO2 Transcritical Booster Refrigeration Systems along with some general system specifications. See additional specifications required and provided by Kysor Warren Epta US and the customer. Additional specifications may include:

- Schedule / Legend of Equipment Load and Electrical Requirements
- Configuration Overview and List of Options ordered
- Sequence of Operations
- Specifications of Components
- Specific Piping Diagram
- Site Specific Installation Drawings

The standard warranty and manual disclaimer are located in Section 7.

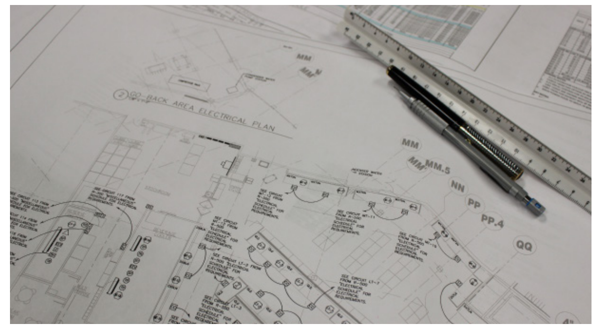

Figure 1-1. Example of schedule / legend of equipament load

NOTE

Customer specifications and local codes take precedence over directions contained in this document. Installation and service that do not comply with this manual may lead to poor performance or reliability, and will void the equipment warranty. Changes to the additional specifications (above) that are not approved by Kysor Warren Epta US will void the warranty of the system. Contact your Kysor Warren Epta US representative to verify the most current version of this manual.

1.2. SYSTEM OVERVIEW

Kysor Warren's line of Carbon Dioxide (CO2) Transcritical Booster Systems provides customers with a cost effective solution for supermarket refrigeration. These systems use naturally occurring, environmentally friendly, and energy efficient CO2 refrigerant. CO2 has a Global Warming Potential (GWP) of 1, zero Ozone Depletion Potential (ODP), and therefore is environmentally friendly and is in compliance with federal environmental regulations

This system utilizes CO2 as a refrigerant in a direct expansion (DX) mode on the evaporators to achieve cooling both for medium temperature (MT) and low temperature (LT) loads. The LT and MT loads are produced with a single, multiple compressor rack that combines subcritical and transcritical compressors in a booster arrangement.

A booster refrigeration system uses two stage compression. The first stage compression discharge is connected to the second stage suction in order to boost the second stage suction pressure. The first stage compression group provides cooling at a lower temperature while the second stage compression group provides cooling at a medium temperature.

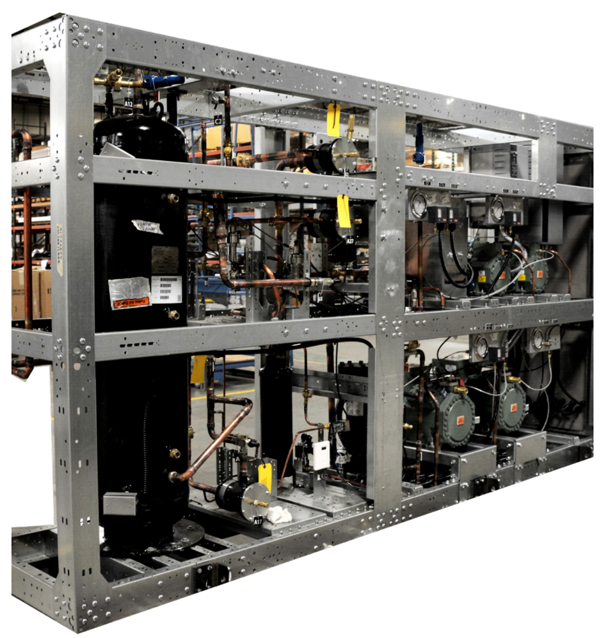

Figure 1-2. CO2 Transcritical Booster System

The system cycle is transcritical because in high ambient temperatures, the heat rejection occurs at pressures and temperatures above the refrigerant's critical point. For CO2, the critical point is 87.8°F (31.0°C) and 1070 psia (73.8 bar). The high side operating pressure in CO2 transcritical systems is higher than conventional CO2 systems - typically, up to 103 bar (1500 psig).

- Liquid CO2 at temperatures around 36.0°F (2.2°C) is distributed throughout the store with insulated piping to provide cooling for each refrigerated case or walk-in box.
- Electronic expansion valves (EEV) control temperatures by metering refrigerant flow into evaporator coils.
- Suction gas from the LT loads returns to the LT compressors on the CO2 parallel rack.
- The gas is compressed to the same pressure as the suction line coming from the MT cases. It is then combined with the medium temperature suction gas and any gas coming from the flash tank.
- Mixture then enters the medium temperature compressors where it is compressed and routed to the Gas Cooler for heat rejection (gas cooling or condensation).
- Upon exiting the Gas Cooler, the refrigerant passes through a high pressure electronic expansion valve (EEV) where the pressure and temperature are reduced to enter the Flash Tank.
- In the flash tank, the gas that is generated during the pressure reducing process is separated from the liquid.
- The residual gas is routed through a Flash Gas Bypass Valve back to the MT compressor.
- The liquid refrigerant is piped to the MT and LT electronic expansion valves.
- The cycle is then repeated. Figure 1-3 displays a schematic of this cycle.

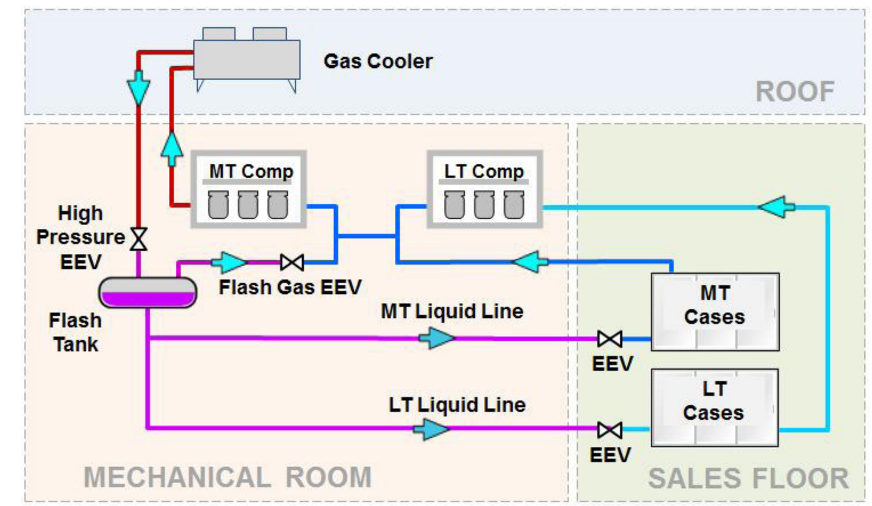

Figure 1-3 . Schematic of a CO2 Transcritical Booster Refrigeration System

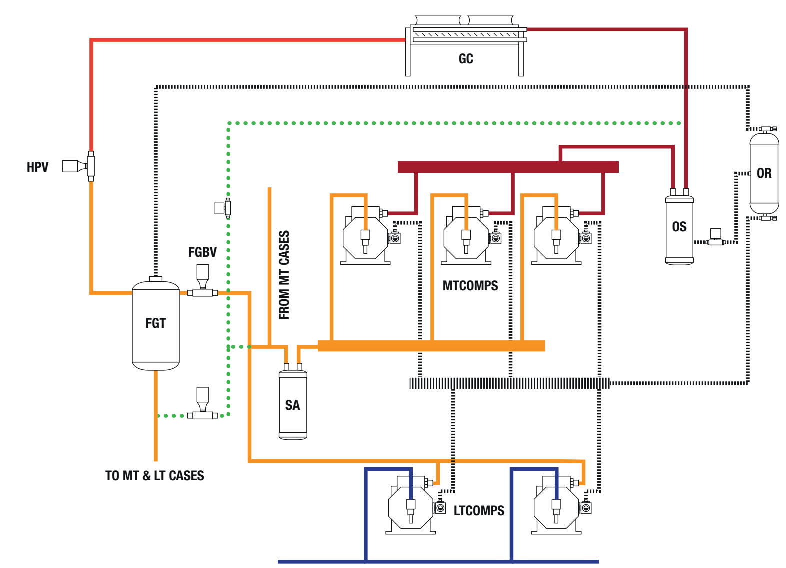

Figure 1-4. Schematic of a CO2 Transcritical Booster Refrigeration System

1.2.1. REFRIGERATION CYCLE

Figure 1.5, Figure 1.6, and Table 1.1 show the CO2 transcritical booster system refrigeration cycle. Figure 1.2 superimposes the state of the CO2 refrigerant on a pressure-enthalpy (p-h) diagram as it cycles through the system. The numbers on the diagram correspond to the numbers in Figure 1-5.

CO2 P-H DIAGRAM

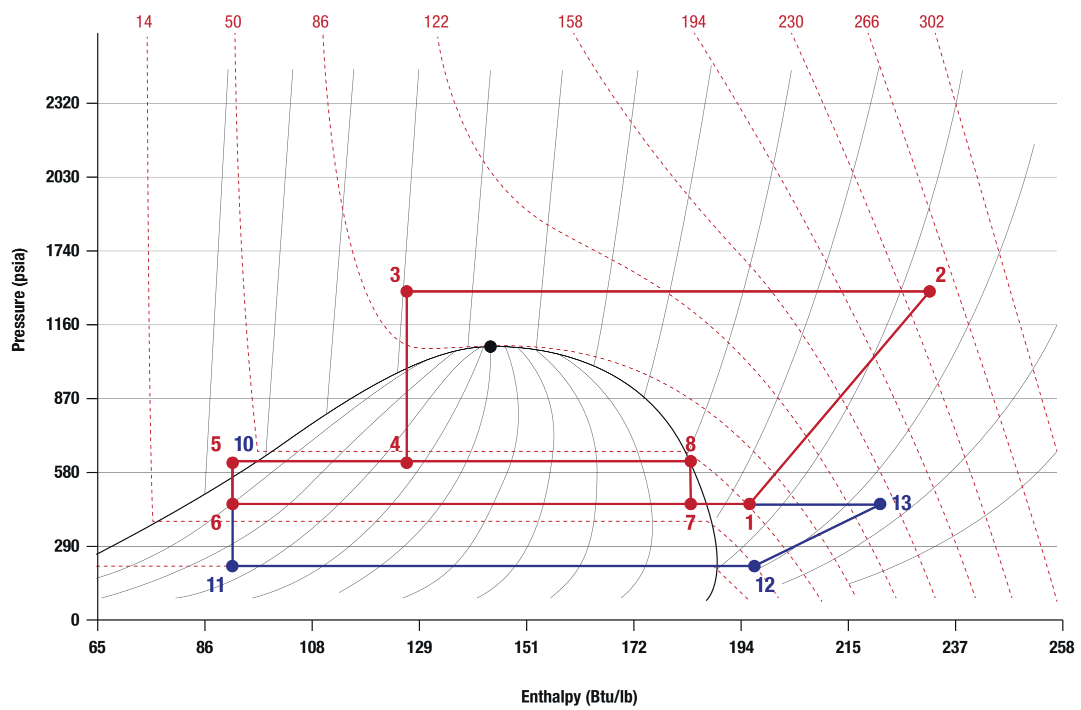

Figure 1.5. CO2 Pressure – Enthalpy Chart with an Example Refrigeration Cycle

EXAMPLE CO2 TRANSCRITICAL BOOSTER REFRIGERATION CYCLE

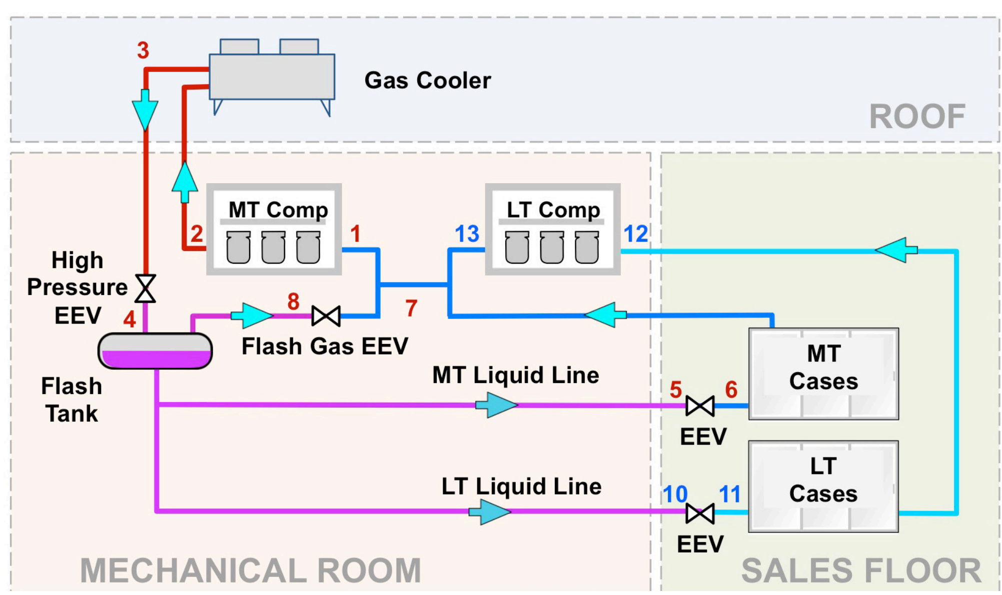

Figure 1-6. Example CO2 Transcritical Booster Refrigeration Cycle

1.2.2. EXPLANATION OF CO2 TRANSCRITICAL BOOSTER REFRIGERATION CYCLE

Using the numbers in Figures 1-5 and 1-6, Table 1-1 explains each step.

Sequence	Description
1 to 2	CO2 refrigerant gas gains pressure and heat though the medium temperature (MT) compressor.
2 to 3	CO2 goes through the condenser/gas cooler and loses heat.
3 to 4	The high pressure electronic expansion valve (EEV) causes the refrigerant to loose pressure. The refrigerant is now a mix of gas and liquid.
Flash Tank	The flash tank allows the refrigerant to be separated into a gas or a liquid. The liquid is piped to the evaporator/cases and the gas is re-routed to the MT compressor.
5 to 6	A proportion of the liquid refrigerant is piped to the MT evaporator/cases and loses heat. The EEV reduces its pressure still more.
4-5-10-11	A proportion of the liquid refrigerant is piped to the low temperature (LT) evaporator/cases. The EEV reduces its pressure still more.
6 to 7 and 11 to 12	In both the LT and the MT evaporators/cases, the liquid refrigerant gains heat, boils and turns into 100% gas.
7-1-2	The refrigerant from the MT evaporators/cases mixes with the refrigerant leaving the LT compressor. It then goes through the MT compressor, gaining pressure and heat.
8-7	Vapor from FGT goes through FGBV an enters into the MT compressors.
12-13-7	The refrigerant, now 100% gas, is piped to the LT compressor where it gains pressure and heat. When it leaves the MT compressor, it mixes with the refrigerant from the MT evaporator/cases and goes to the MT Compressor.
	The cycle then begins again.

Table 1-1. The Cycle of the CO2 Transcritical Booster Refrigeration System

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

1.3. PRIMARY COMPONENTS AND SUBCOMPONENTS

The CO_2 Transcritical Booster Refrigeration System is comprised of following subsystems subsystems, or modules:

- LT compressor module
- MT/Transcritical compressor module
- Refrigerant management module
- Oil management module

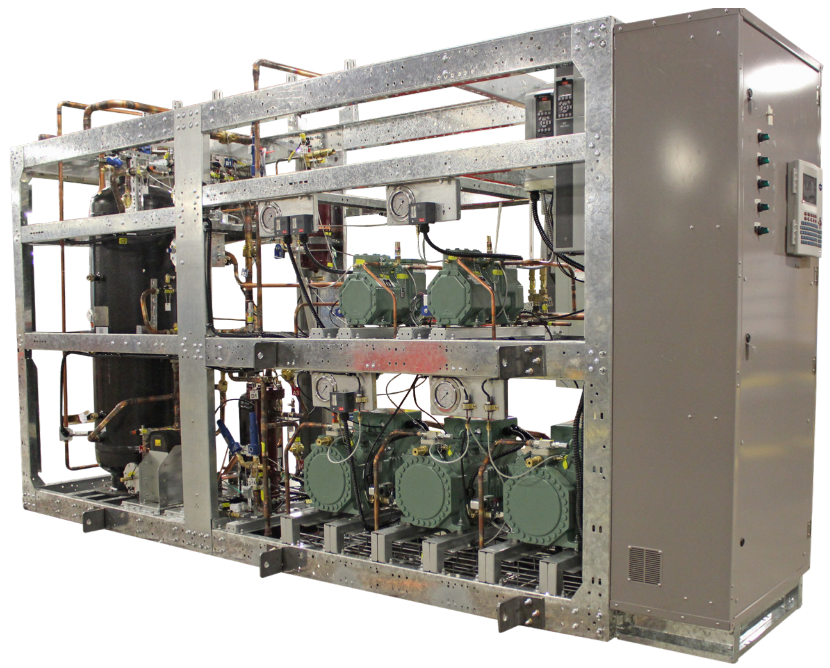

Figure 1-7. Primary Modules and Components for a CO_2 Transcritical Booster Refrigeration System

1.3.1. LT COMPRESSOR MODULE

The low temperature (LT) compressor group:

- Compresses the return gas to the same pressure as the MT compressors.
- The compressors can be either semi-hermetic reciprocating or hermetic scroll type compressors
- This compressor group is controlled to a pre-defined suction pressure set point according to design conditions and by staging compressor capacity.

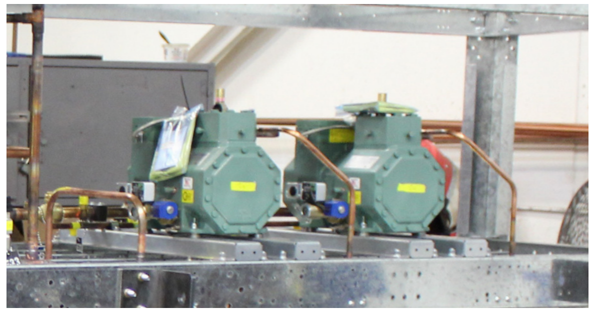

Figure 1-8. Low temrerature compressor (LT)

> The standard Kysor Warren CO_2 TC Booster racks offer design pressures of **435/769 psig (30/53 bar)** for semi-hermetic reciprocating compressors and **406/625 psig (28/43 bar)** for the North American market or **435/652 psig (30/45 bar)** for the European market on the Scroll compressors.

NOTE

Kysor Warren also offers and optional design with high stand still semi-hermetic reciprocating compressors on the LT compressor group capable of sustaining 957 psig (66 bar) USA, and 1305 psig (90 bar) Europe stand still pressures.

- A variable frequency drive (VFD) may be added for a smoother capacity control on the lead compressor when semi-hermetic compressors are used. When using hermetic scrolls, a digital compressor can be used for capacity modulation.

1.3.2. MT/TRANSCRITICAL COMPRESSOR MODULE

- The medium temperature (MT) compressor group elevates the pressure of the combined flows coming from the MT loads, LT compressor group discharge, and Flash Gas Bypass line up to the gas cooler pressure level.
- The type of compressor used in all designs for Kysor Warren products are semi-hermetic reciprocating compressors.

Figure 1-9. Medium temrerature compressor (MT)

> These compressors are typically designed to withstand pressures exceeding the system design pressures of **1740 psig (120 bar)** on the high side, and **652 psig (45 bar)** for the Intermediate Pressure Stage.

- Capacity control of this compressor group is attained by maintaining a pre-defined suction pressure set point according to design conditions and by staging compressor capacity.
- A variable frequency drive VFD is added for a smoother capacity control on the lead compressor.

1.3.3. REFRIGERANT MANAGEMENT MODULE

This module manages the high side pressure, the flash tank pressure, the refrigerant storage, and liquid-vapor separation. It is made up of a High Pressure Expansion Valve (HPEV), Flash Tank, Flash Gas Bypass Valve (FGBV), and interconnecting piping.

HIGH PRESSURE EXPANSION VALVE (HPEV)

The HPEV is an electronic expansion valve responsible for controlling the gas cooler outlet pressure in transcritical operation mode for optimum energy efficiency.

This valve also is responsible for reducing the pressure of the CO_2 coming out of the gas cooler to the flash tank pressure levels. During this pressure reducing process, vapor is formed as a result of the cooling of the CO_2 and a colder vapor-liquid mixture is encountered at the outlet of the valve.

Depending on ambient temperatures the vapor fraction in this mixture can be as high as 45-55%.

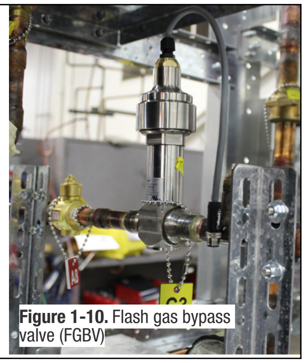

Figure 1-10. Flash gas bypass valve (FGBV)

FLASH TANKS

Flash tanks are pressure vessels just like a receiver in a standard CO_2 refrigeration system with similar functions. They:

- Hold the refrigerant charge of the system to guarantee proper operation of the system throughout the entire change of conditions in a year.
- Physically separate the refrigerant liquid and gas phases so that only the liquid is sent to the loads and the vapor can be redirected to the MT compressor suction through FGBV.
- Can be either vertical or horizontal. A vertical flash tank is the standard design due to its effectiveness in phase separation.

Figure 1-11. Flash tank

FLASH GAS BYPASS VALVE (FGBV)

A flash gas bypass valve (FGBV) is an expansion valve that controls the flash tank pressure.

- It opens or closes according to a set point.
- If the amount of flash gas generated by the HPEV increases or decreases due to ambient conditions, the pressure in the tank will fluctuate around the set-point.
- The FGBV also reduces the pressure of the bypass gas in order to match the valve outlet pressure with the MT compressor suction pressure.

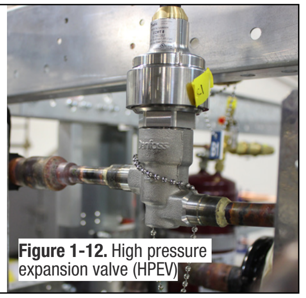

Figure 1-12. High pressure expansion valve (HPEV)

1.3.4. OIL MANAGEMENT

Oil is essential for the reliability of the compressors in a refrigeration system as well as lubricating seals. As compressors pump refrigerant they also pump a small amount of oil with it. The volume of oil in refrigerant lines and heat exchangers displaces refrigerant volume, and reduces the efficiency of the system. To avoid trapping oil in other parts of the system and depleting the oil level in the compressors, it is important to recover it and properly return it to the compressor crankcase.

The oil management system of Kysor Warren's CO2 TC Booster racks includes a common oil separator with electronic oil management at the discharge side of the MT compressors group. Also included in this module are: an oil transfer and pressure reducing valve, an oil reservoir, an oil filter and electronic oil level regulators for replenishing the oil according to the demand by each individual compressor.

A coalescing type oil separator is used to provide very high efficiency, usually above 97%, oil recovery. This oil separator is equipped with an oil level switch, which triggers the opening of the oil transfer and pressure reducing valve. The valve opens when it senses oil at the bottom of the separator and transfers the oil to the reservoir. The oil transfer and pressure reducing valve is a normally closed solenoid valve with a small port to cause the pressure drop from the discharge to the flash tank pressure level.

The oil reservoir is a standard pressure vessel for oil storage and supply to the compressor crankcase. The electronic oil level regulators use a level switch mounted at the sight glass port of the compressor to detect the oil level inside of the compressor. When the oil level falls below the sensor, a solenoid valve opens allowing oil flow to the compressor crankcase.

Figure 1-13. Oil reservoir

Figure 1-14. Coalescing oil separator

The oil separator and pressure reducing valve are rated for **1740 psig (120 bar)** or more. Downstream of the oil transfer valve, all components are rated for the design pressure of the liquid lines in the system, typically **652 psig (45 bar)** except in the special case of high stand still pressure design.

REMOTE GAS COOLER/CONDENSER

Gas Coolers cool the CO2 refrigerant to near ambient temperature. Above the critical point, CO2 gas does not condense, so there is no phase change. The CO2 remains as a single phase gas from the inlet to the outlet as the temperature is reduced. Gas coolers come in different forms and functions. The most commonly used are air cooled gas coolers. Systems in dry climates could benefit by adding evaporative assisted cooling. The efficiency of any gas cooler varies with the climate. At lower ambient temperatures, when CO2 is below the critical point, a gas cooler operates as a conventional condenser and phase change occurs from vapor to liquid.

Figure 1-15. Remote gas cooler/condenser

1.4. OPTIONAL COMPONENTS

AUXILIARY CONDENSING UNIT (OPTIONAL)

The optional Auxiliary Condensing Unit (ACU) functions as an optional auxiliary pressure control for the flash tank in case of main power outage. It runs off of the main electrical power and backup power (generator) during power outages. Even though the flash tank is properly insulated, heat transfer will occur from the surrounding atmosphere and into the flash tank. When the CO2 inside the flash tank absorbs heat, vapor is generated causing pressure to rise. The purpose of ACU is to keep the pressure inside the flash tank below the relief valve setting(s).

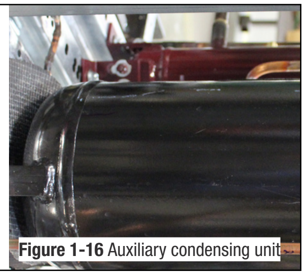

Figure 1-16 Auxiliary condensing unit

LT SUCTION LINE HEAT EXCHANGER (OPTIONAL)

A heat exchanger between the low temperature liquid supply and the low temperature suction gas return is provided as an optional feature of Kysor Warren CO2 TC Booster Racks in lieu of a suction accumulator. It protects the LT compressor group from liquid slugging in low superheat conditions. This component is a Brazed Plate Heat Exchanger (BPHE) for compactness and heat transfer effectiveness.

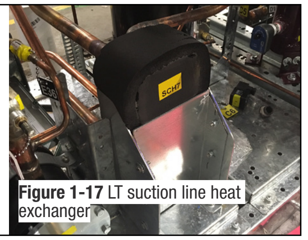

Figure 1-17 LT suction line heat exchanger

SUCTION ACCUMULATOR (OPTIONAL)

Suction accumulators are used as a protective vessel to prevent liquid refrigerant from flooding the compressor. The accumulators are vessels used to separate gas from liquid. It is placed in between the compressor suction and MT/LT evaporator. If a mixture of gaseous and liquid refrigerant flows from the evaporator to the accumulator, the liquid by gravity precipitates at the bottom of the accumulator and the gas flows towards the compressor suction through a port at the top of the accumulator.

Figure 1-18 Suction accumulator

PARALLEL COMPRESSION SYSTEM (OPTIONAL)

Parallel compression is an improved cycle configuration of CO2 Transcritical Booster refrigeration systems for warm climates. In this configuration – see Figure 1-6, instead of routing the flash gas to the MT compressors suction, it connects the flash gas bypass line directly to a group of compressors without dropping the pressure through the FGBV.

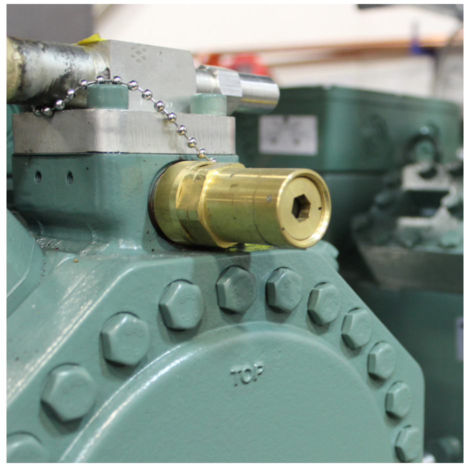

Figure 1.19. Parallel compressor

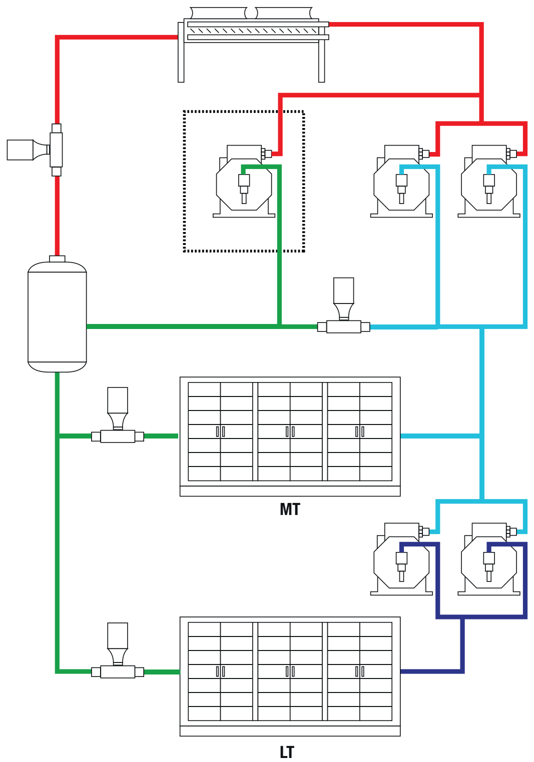

Figure 1-20. Parallel compression system diagram

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SAFETY

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SAFETY

KW highly recommends that clients using these products have a strong safety program. The keys to the safe operation of a refrigeration system are:

- A visible and vigorous safety program
- The installation and operation of the system with all safety concerns recognized, evaluated and incorporated.
- Well trained and competent operators.

2.1. GENERAL SAFETY CONSIDERATIONS

- The installation, commissioning, maintenance and disassembly must be carried out by trained and qualified personnel with sufficient knowledge of this type of equipment.
- When maintenance is performed, equipment is pressurized with dry air or inert gas.
- All equipment piping must be evacuated before charging the system with refrigerant.
- Make sure that all field wiring conforms to the requirements of the equipment and all applicable national and local codes.
- Avoid contact with sharp edges and coil surfaces. They are a potential injury hazard.
- Before working on the system, make sure all power sources are disconnected.

2.2. ON SITE WARNING SIGNAGE

Owners are responsible for display of cautionary / safety signage. Caution signage should be installed on the premise at entrances to the equipment room or areas near installed equipment.

Figure 2-1. Examples of cautionary and safety signage

2.3. PERSONAL PROTECTIVE GEAR

Technicians and support staff are responsible for using proper protective gear. It is recommended that all staff working on this type of installation to use the personal protective equipment (gloves, glasses and safety shoes).

Figure 2-2. Examples of types of protective equipment

2.4. CO2 SAFETY AND ENVIRONMENTAL CHARACTERISTICS

CO2 is unique among natural refrigerants for having good safety characteristics. It is non-flammable, non-explosive, and relatively non-toxic. It exists naturally in the atmosphere at concentrations around 400 ppm. These characteristics makes it an almost ideal fluid, especially for applications where relatively large quantities of refrigerant are needed. As a natural substance, CO2 has no Ozone Depletion Potential (ODP) and a GWP of 1. It is classified in safety group A1, according to ASHRAE Handbook-Fundamentals. This group contains the refrigerants that are least hazardous and least toxic.

2.4.1. CO2 CONCENTRATIONS

According to ASHRAE 34, a CO2 concentration of 1000 ppm is the recommended limit to ensure the comfort for the occupants (the higher concentration than found naturally (400 ppm) may be the result of human activities or the use of machinery). In a CO2 controlled ventilation system therefore, fresh air should be supplied so that the CO2 concentration level does not exceed 1000 ppm. A very high leakage rate in indoor supermarket spaces or in the machine room however, could result in hazardous health conditions and additional safety measures are required.

OSHA lists 5000 ppm as the TLV-TWA (Threshold Limit Value – Time Weighted Average). Table 2-1 is a list of selected concentration levels of CO2 and the expected effects on human health.

CO2 Concentration		Symptoms and Effects on Humans
%	ppm	
0.04%	400	Normal concentration in the atmosphere
0.1%	1000	Recommended upper limit for comfortable indoor air quality
0.5%	5000	8 hours – long term exposure limit TLV-TWA (OSHA)
1%	10,000	Drowsiness
1.5%	15,000	10 minutes – short term exposure limit TLV-TWA
2%	20,000	50% increase of breathing
3%	30,000	OSHA STEL 10 minute TWA exposure, 100% increase of breathing
5%	50,000	IDLH – Immediate Danger to Life or Health
10%	100,000	Lowest lethal concentration, few minutes' exposure causes unconsciousness
30%	300,000	Brief exposure causes unconsciousness and death

Table 2-1. CO2 concentrations and Their Effect on Humans

2.4.2. SAFETY CONCERNS RELATED TO OTHER CO2 PROPERTIES

CO2 has certain unique physical properties that require additional specific safety considerations. Solid CO2 is commercially available in the form of dry ice or snow and can cause severe frost burn if not handled with care and the use of suitable personal protective equipment. Liquid CO2 has a very high coefficient of thermal expansion. Care must be taken to ensure that liquid CO2 is not trapped in pipelines between shut off devices. An increase in the temperature of trapped liquid will cause hydrostatic expansion that can generate sufficient pressure to rupture pipes and components.

Molecular Weight	44.01 g/mol
Boiling Point (sublimation) @ 1 atm.	-109.1°F (-78.5°C)
Triple Point Temperature	-69.8°F (-56.6°C)
Triple Point Pressure	75.2 psia (5.19 bar)
Critical Pressure	1070 psia (73.8 bar)
Critical Temperature	+88°F (+31°C)
Specific Gravity @ 1 atm.	1.53
Saturation Pressure @ +21°F (-6°C)	430 psia (29.632 bar)
Liquid Density @ +21°F (-6°C)	60.04 lb/cf (961.7 kg/m³)
Vapor Density @ +21°F (-6°C)	5.04 lb/cf (80.77 kg/m³)
Saturation Pressure @ -22°F (-30°C)	207 psia (14.278 bar)
Liquid Density @ -22°F (-30°C)	67.15 lb/cf (1075.7 kg/m³)
Vapor Density @ -22°F (-30°C)	2.32 lb/cf (37.098 kg/m³)
Safety Limit of CO2 in air (OSHA TLV-TWA)	5000 ppm (0.5%)

Table 2-2. Selected Properties of CO2

2.4.3. CO2 SUPPLIERS – NORTH AMERICA

AIR LIQUIDE AMERICA L.P. 2700 Post Oak Boulevard, Suite 1800 Houston, TX 77056 866-822-5638 Website www.airliquide.com
LINDE GAS 6055 Rockside Woods Blvd Independence, OH 44131 216-642-6600 www.us.lindegas.com
PRAXAIR, INC. 39 Old Ridgebury Road Danbury, CT 06810 203-837-2000 www.praxair.com
AIRGAS 2530 Sever Road, Suite 300 Lawrenceville, GA 30043 800-473-3766 www.airgasrefrigerants.com

Table 2-3. Suppliers of CO2 Refrigerants in the United States

2.4.4. CO2 GRADES

Carbon Dioxide is produced as a byproduct of a number of different manufacturing processes including the formation of hydrocarbons and various distillation and fermentation processes. CO2 also naturally exists in wells. After the CO2 gas has been isolated, it is purified into different levels through the filtration of impurities and removal of moisture and non-condensable gases that result in different grades of CO2 for different applications. Examples of various grades of CO2 are shown in the table 2-4 below.

@	Grade	% Purity	H2O#	THC#	Ar#	CO#	N2#	O2#
**	SFE	99.9995	1	0.5	1	1	5	1
**	SFC	99.999	3	1	1	1	5	1
**	Research Plus	99.999	2	0.5			4	1
**	Research	99.999	3	1	1	1	5	1
**	Semi conductor	99.995	5	5				
**	LaserPlusTM - Ultra	99.996	5	1				10
**	LaserPlusTM	99.995	5	5				
**	Pure Clean	99.995	5	5				
*	LaserTM -	99.99	10	10			70	20
*	Refrigerant	99.99	10					
*	Instrument/ Coleman	99.99	10	10			70	20
NO	Anaerobic	99.9			10			10
NO	Bone Dry	99.9	10					
# Concentrations shown in ppm unless otherwise specified. Source – Air Gas								

Table 2-4. CO2 Grades

Coleman grade * (or higher purity**) CO2 refrigerant which contains less than 0.01% impurities are recommended by Kysor Warren for use in CO2 Transcritical booster refrigeration systems. Carbon Dioxide used in refrigeration systems must be of sufficient purity to prevent accumulation of non-condensable gases and moisture in the condenser-evaporator. A build-up of these impurities can block heat transfer surfaces and cause inefficient operation or malfunction of the system.

2.5. SAFETY RELATED COMPONENTS

CO2 transcritical booster refrigeration systems have several safety components installed throughout the systems. Primary ones include:

- Leak detection systems
- Pressure relief valves
- System overpressure protection

2.5.1. LEAK DETECTION SYSTEMS

CO2 has one main drawback in not being self-alarming: it does not have a distinctive odor or color. This implies that facilities where CO2 may leak must be equipped with sensors that trigger an alarm when the concentration level exceeds 5000 ppm, to avoid an adverse health condition.

Since CO2 is heavier than air, the sensors and ventilators in the space where CO2 might leak should be located close to the floor.

In the event of a detection of high CO2 concentration levels, the control system may be configured to turn off compressor(s), pump (s) and/or close control valve(s) or run purge ventilation in addition to initiating the personnel alarm system(s).

CO2 refrigerant is inexpensive and relatively safe, so designs can be less sensitive to leaks or large refrigerant charges. Nevertheless, CO2 components and lines generally result in lower volume charge when compared to systems using other refrigerants.

The leak detection systems usually require the user to preset the type of gas while installing the leak detection system, to avoid false alarms. The following leak detection systems are used with Kysor Warren Epta US Refrigeration Systems:

- Emerson RLDS/MRLDS
- Danfoss GDC IR 10000/40000
- Vaisala CO2 leak detector

These systems can detect CO2 concentration as low as 5 to 20 ppm. Other handheld devices for detecting CO2 leaks are not as accurate. When a leak occurs in the liquid lines of the system, it becomes visible as a cloudy vapor emission. This is due to the condensation of moisture in the air surrounding of the leak. **The installed design of leak sensors must comply with local codes and regulations.** Figure 2-3 shows an example.

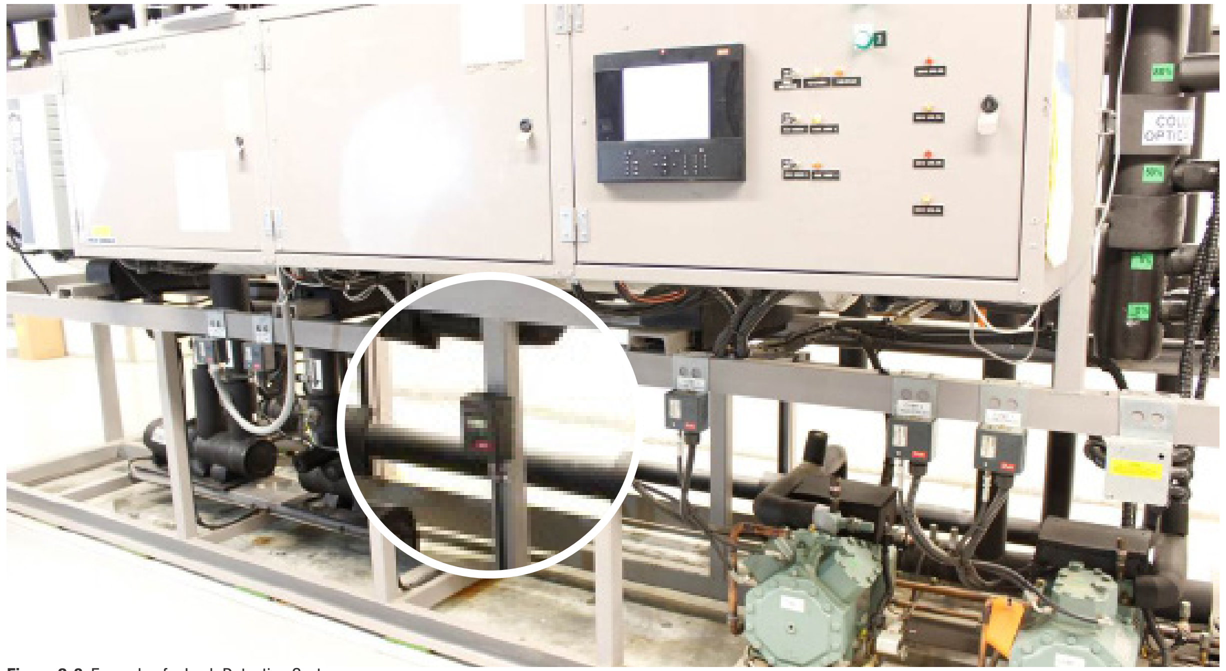

Figure 2-3. Example of a Leak Detection System

2.5.2. PRESSURE RELIEF VALVES (PRV)

Pressure relief valves provide safety measures during circumstances such as power outages, natural disasters, or system malfunction that may cause abnormal operation and high pressure in the system. When the pressure exceeds the designed set-point, the valve opens relieving the pressure to a safe level.

The figure below shows a pressure relief valve that is spring loaded to counter the refrigerant flow through the inlet nozzle. The set point pressure can be set within a pressure range (depending on the PRV) with the help of pressure adjusting screw at the top of the valve. When the pressure at the inlet nozzle breaches the set point pressure, the force applied by the refrigerant push open the valve seat to allow flow through the PRV, reducing the system pressure, safeguarding it from damages. PRV are selected to operate in specific locations in the system. Relief valves are sealed by the manufacturer and should never be adjusted in the field. These should only be installed or replaced according to Kysor Warren Epta US specifications. The installed design must comply with local codes and regulations.

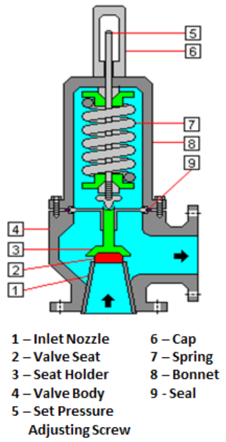

Figure 2-4 . Pressure Relief Valve

Figure 2-5. Dual Manifold Pressure Relief Valve

2.5.3. SYSTEM OVERPRESSURE PROTECTION

The Kysor Warren Epta US CO2 Booster system includes some safeguards to ensure that pressures do not exceed design limits. There are a few conditions that could cause high pressure in the system.

- Discharge line blockage – MT or LT
- System shutdown – all low and intermediate pressure affected

The CO2 Booster systems have several layers of protection for each condition.

Discharge Line Blockage

Medium Temperature

- Rack controller set at 1435 psi (99 bar) – shuts down
- High pressure switch at 1570 psi (108 bar)– shuts down
- Pressure relief valve set at 1740 psi (120 bar) – releases refrigerant

Low Temperature

- High pressure switch at 480 psig (33 bar) – shuts down
- Pressure relief valve set at 625 or 652 psig (43 or 45 bar) – releases refrigerant

System Shutdown

If the CO2 refrigeration system is damaged and not operational, the pressure will tend to rise to nearly the saturated pressure corresponding to the warmest ambient exposure. The system design has several features to prevent this.

Flash tank

- **Pressure relief valve:** If pressure rises to the limit of the pressure rating of the flash tank, a pressure relief valve will release the refrigerant to the outside.
- **Auxiliary Cooling Unit, ACU (Optional):** For 652 psig (45 bar) rated flash tanks, N|vru Zduuhq Hswd XV offers an optional addition of an auxiliary cooling unit that automatically starts if high pressure is sensed on a mechanical pressure switch installed on the flash tank. The ACU unit will then condense and cool the CO2 gas to maintain the design pressure of the flash tank.

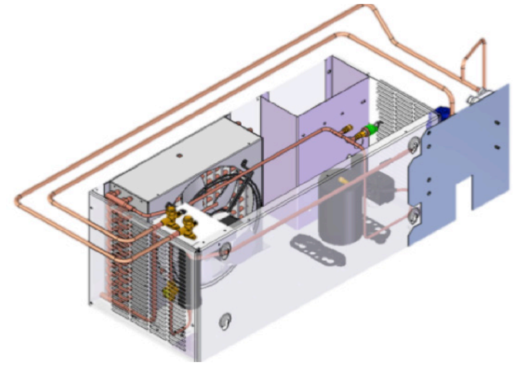

Figure 2-6 . Auxiliary Cooling Unit

Suction lines

Pressure relief valves: If pressure rises to the limit of the pressure rating of the pipes, a pressure relief valve will release the refrigerant to the outside as means to control the pressure in the lines. The pressure settings are:

- **MT:** 970 psig (66 bar) for Semi -Hermetic Copeland and 1305 psig (90 bar) for Semi-Hermetic Bitzer.
- **LT:** 435 psig (30 bar) for Semi -Hermetic Bitzer and 406 psig (28 bar) for Scroll Copeland.

Discharge lines

- **MT:** same layer of protection as for High Ambient Temperatures
- **LT:** Pressure relief valve shared with the MT suction piping

Optionally, all pressure relief valves outlets in a CO2 Transcritical Booster Systems from Nysor Warren Epta US can be connected to a relief valve header by flexible hoses in order to avoid injury to personnel that may be standing close to the rack during a discharge event. The PRV header is field piped to the outdoors in order to disperse the gas during a discharge.

NOTE

The installed design must comply with local codes and regulations (reference ASHRAE 15).

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3

INSPECTION AND **PLACEMENT OF MATERIAL**

KYSOR WARREN

3. INSPECTION AND PLACEMENT OF MATERIAL

Materials at the construction site should be thoroughly inspected upon unloading for damage, missing parts and serviceability.

3.1 INSPECTION OF MATERIALS

Inspect the CO2 refrigeration system and accessories for damages or shortages before and during unloading.

If there is any damage, notify the carrier immediately and request an inspection. Ensure:

- The delivery receipt is annotated that the equipment was received damaged.
- If damage is not noticeable on receipt, contact the carrier immediately when the damage is discovered.

It is the responsibility of the consignee to file all claims for damage with the transportation company.

3.1.1. ACCESSORIES

Be sure that you receive all items. Accessories may be packaged separately.

Check the packing list against the contents.

☐ All parts are present.

> **NOTE**
>
> If parts are missing, contact the Technical Sales Support (TSS) or the point of contact listed in the packing list.

3.1.2. SYSTEM PRESSURE

☐ Pressure in the system is within specified limits.

> **NOTE**
>
> The system is shipped with a 50 psi holding charge of dry nitrogen. Report lack of or a reduced pressure immediately to the Kysor Warren technical sales support.

3.1.3. ELECTRICAL

☐ Specifications on electrical rating plate matches on-site power configuration.

3.1.4. COMPATIBILITY OF FIELD INSTALLED MATERIAL

☐ Field installed material meets manufacturer's specifications.

3.1.5. MATERIALS MEET SPECIFIED PRESSURE RATINGS

☐ Field Installed material meets specified pressure ratings.

3.2 RATING PLATE

The rating plate (Figure 3-1) provides information for the model. Verify the information on the rating plate corresponds to the model ordered.

☐ The model on rating plate is the same as the model ordered.

☐ The supply voltage is the same as required by the unit.

☐ The refrigerant is correct.

☐ The maximum and minimum design pressures match.

☐ The number and specifications for each compressor is correct.

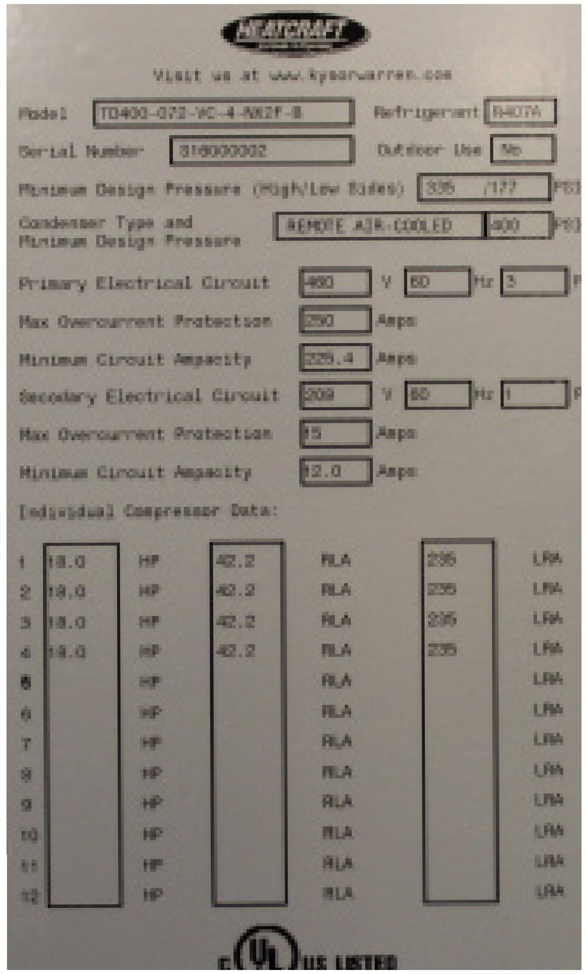

Figure 3-1 . Sample Rating Plate

> **NOTE**
>
> Each rack has a rating plate and a legend on the front or the inside of the electrical panel

3.3 LIFTING INSTRUCTIONS

Each rack system has lifting lugs built into the structure. Failure to lift the unit properly can cause damage to the unit or bodily harm to people in the area.

☐ Spreader Bar(s) are used for all rigging to avoid damaging the equipment.

☐ Use ALL lifting lugs provided on equipment.

☐ Lifting cables and other lifting equipment should not be in contact with piping or electrical components.

☐ Adjust tension on the lifting straps to equalize the weight of the rack when lifted.

☐ Before draining water, ensure that adequate drainage is installed behind the unit to collect and properly discharge the water.

☐ Unpack the unit at the installation site.

3.4 PLACEMENT OF EQUIPMENT

Good positioning at the site of the refrigeration equipment:

• Reduces costs.

• Permits the free flow of air around the system.

NOTE

KW provides information on the equipment weight and the location of lifting lugs. It does not provide detailed lifting instructions because:

- Of the wide variety of conditions and equipment at the construction site.
- The responsible personnel on site are best qualified to determine the specific materials required to lift the equipment.

3.4.1. RACK SYSTEM

Outdoor Location of Equipment

☐ The mounting platform or base is level and permits free air flow. (also see recommendations for free air flow).

☐ Units are not located near steam, hot air or fume exhausts.

☐ The unit is mounted away from noise sensitive spaces such as offices.

☐ The unit has adequate support to avoid vibration and to reduce noise transmission into the building.

LIFTING EQUIPMENT

Kysor Warren Epta US provides information on the weight of the equipment and the location of lifting lugs. Being at the site, the contractor is best qualified to determine the specific materials required to lift the equipment. Figure 3-2 shows an example of a shackle attached to a lifting lug. Figures 3-3 and 3-4 show examples with a front and side view, of the lifting arrangement for a refrigeration equipment.

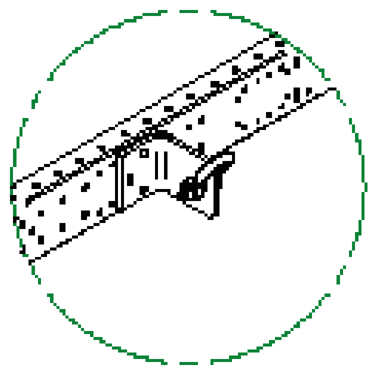

Figure 3-2. Example of a shackle and Lifting Lug

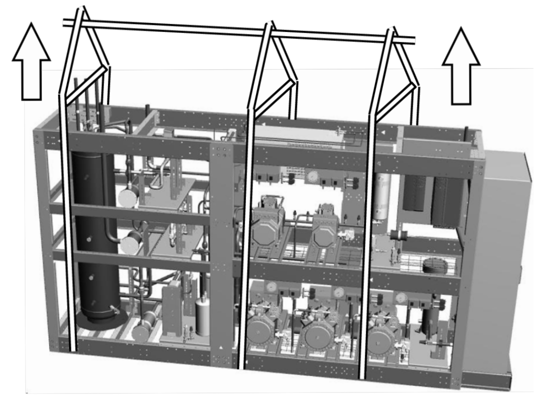

Figure 3-3. Rigging arrangements

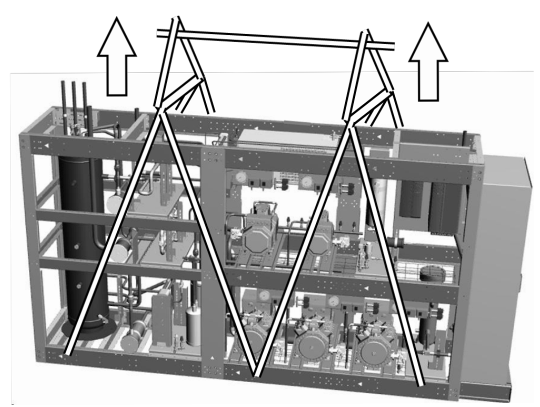

Figure 3-4. Rigging arrangements

Equipment Mounted on the Ground

Figure 3-5. Rack system mounted on the ground

The foundation is:

☐ Set on a flat and level foundation

☐ Is designed to support the weight of the equipment

☐ Isolated from the building structure.

☐ Rechecked to ensure it is level prior to tightening the bolts.

Equipment Mounted on the Roof

☐ The structure is strong enough to support the weight of the unit and service personnel.

☐ The structure minimizes deflection and vibration transmission

Ventilation

☐ Ventilation is in the range of 40-100cfm per compressor horsepower depending upon ambient temperatures or as specified by the customer.

☐ The air intake is positioned and sized so that air passes over the units at a maximum velocity of 500ft/minute velocity.

☐ Check national and local codes and use the larger of the manufacturer's recommendations and national/local codes.

Figure 3-6. Example of a Vibration Isolation Pad

Figure 3-7. Example of a Vibration Absorbing Spring Mount

Reducing Vibration

☐ Vibration isolation pads are used.

☐ Isolation hangers are used when refrigeration lines are suspended from the structure.

☐ Packed fiberglass and sealing compound are used when piping passes through walls.

☐ If required, special vibration absorbing spring mounts (optional equipment), Figure 3-7 are placed under the base frame of each unit.

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4

SYSTEM ***INSTALLATION***

KYSOR WARREN

4. SYSTEM INSTALLATION

4.1. GENERAL

Installation of the refrigeration must comply with the “Safety Standard for Refrigeration Systems” (ANSI/ASHRAE Standard 15), ASME B31.5 Refrigeration Piping Standard, and local building codes.

> **NOTE**
>
> Customer is solely responsible for compliance with local codes and regulations.

- Properly sized refrigeration lines are essential. Suction lines are more critical than liquid or discharge lines. Consult the technical manual or legend sheet for proper line sizes.
- Do not run refrigeration lines from one system through cases on another system.
- Refrigeration lines should never be placed in the ground unless they are protected against moisture and electrolysis attack.
- Main trunk lines should enter a line-up of cases in the center.

4.2. RESPONSIBILITIES

Responsibilities for the installation of the refrigeration systems are divided between Kysor Warren, the store owner, and the installer (Table 4-1).

Action	N|vru Zduuhq Hswd XV	Store Owner	Installer
Code compliance		X	
Caution Signage per Local Code		X	
Inspection of material			X
Component specifications	X		
System Specifications	X		
Store Layout		X	
Installation of System			X
Interconnection of System			X
Operational Testing			X

Table 4-1. Responsabilities

4.3. FIELD PIPING

4.3.1. PIPE LINE SIZING

☐ Piping lines are installed according to the drawings and customer specifications

☐ Changes to diameters and materials are confirmed and documented

4.3.2. PIPE PRESSURE RATINGS

This specification is used in conjunction with the customer specifications. It is intended to supplement and clarify the scope of work and technical specifications for field refrigerant piping for Transcritical CO2 Booster Refrigeration System as well as leak testing, approval of local authorities, charging, start-up and commissioning of the entire system. It includes piping between WEM (Weather Enclosure Mechanical) and display cases / walk-in coolers / freezers including installation of flow control valves, circuit solenoid valves, full-port ball valves with bypass return check valve, etc.

> **NOTE**
>
> Site specific installation drawings take precedence over these guidelines

CO2 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. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation. Table 4-2 shows sections of the CO2 Transcritical Booster Refrigeration System with related pipe material rated for the operating pressure and temperature. See Section 1 for typical CO2 Transcritical Booster System operating pressures and temperature. The maximum pressures in this table and the design pressures in table 1.2 are similar but they do not exactly match

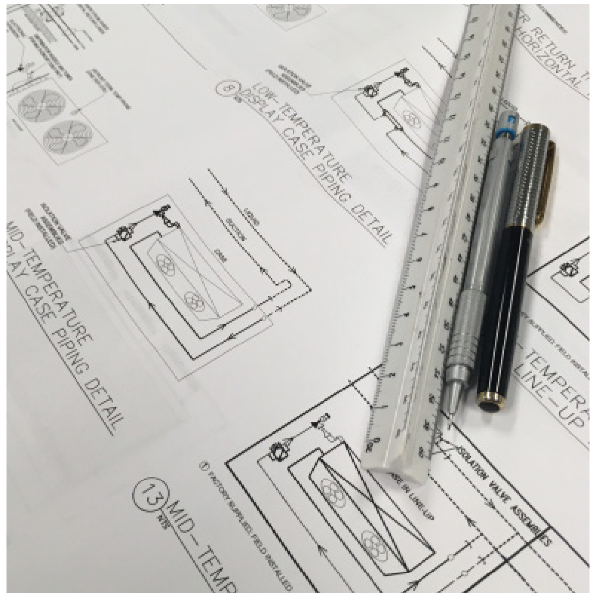


Figure 4-1. Piping schematics

Section	Max Operating Pressure (1) psi (bar)	Max Operating 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 Temperature 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 (2)	435 (30)	-22°F (-30°C)	

(1) Pressure relief valves limit pressure

(2) For consistency, 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

Table 4-2. CO2 Piping Requirements

> **NOTE**
>
> The installed design must comply with local codes and regulations.

4.3.3. CASE AND UNIT COOLER PIPING

CO2 Case and Unit Cooler piping & instrumentation is similar to conventional refrigeration systems. For multiple cases, the liquid distribution and suction gas pipelines are preferably internally installed but can be externally installed.

Liquid Lines

The CO2 liquid lines must be rated for 652 psig (45 bar). Since the lubricant is miscible with the liquid refrigerant, these lines do not require special arrangements for oil return. Customer specifications are properly designed in order to achieve the preferred velocity and minimum pressure drop. Increasing pipe sizes result in greater demand of refrigerant and decreasing pipe sizes results in a higher pressure drop. Refer to site-specific piping installation drawings for liquid piping. Systems without subcooling features require special pipe routing and connections to handle two phase refrigerant.

Suction Lines

Suction lines carry expanded vapor back to the compressor from the evaporators, and should be insulated. The suction lines may travel horizontally or vertically to the refrigeration rack. Any suction line that travels vertically and the direction of refrigerant flow is against gravity, is called a suction riser. Refrigerant flowing through suction risers may be unable to carry the lubrication oil through the pipes to the compressor due to the low flow velocity. Oil traps are therefore designed into the suction risers.

Isolation Valves

If the customer requires isolation valves for individual circuits, they must be 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. Contractor should obtain verification (sign-off) from the customer construction manager to confirm the proper direction before proceeding with the insulation. The bypass check valves are required for instances when the isolation valves are closed while the pressure of the refrigerant rises. In these cases the check valves open up and distribute the pressure (towards the rack) avoiding any damage to the pipelines and other equipment. Figure 4-2 illustrates the positioning of check valves

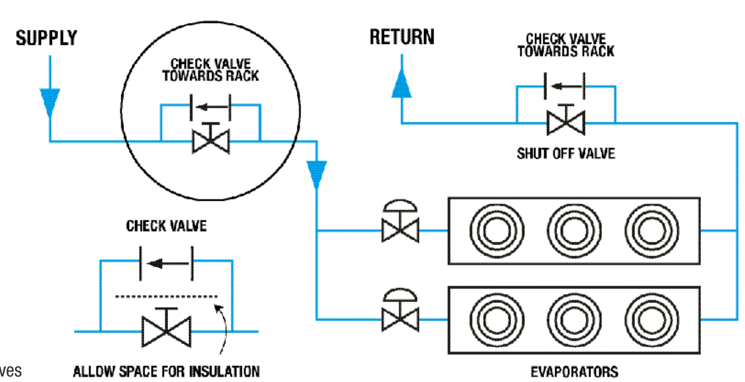


Figure 4-2. Positioning of Check Valves

Relief Valve Installation

Relief valves should exhaust to exterior locations to comply with ASHRAE 15. Valves must be located and oriented so that they discharge pressurized refrigerant safely and away from personnel. N|vru Zduuhq Hswd XV CO2 Booster racks have relief valves along with relief valve headers that comply with ASHRAE 15 standards.

Sloping Lines

All CO2 suction return lines must be installed with a slope or pitch downward of 1 inch per 20 feet towards the machine room. If liquid lines are run with suction return lines, they may also be sloped. This is a common practice for conventional CO2 systems to enable the return of refrigerant oil.

4.3.4. EXPANSION JOINTS

Expansion joints should be designed into the system to provide strain relief. Piping strain and stress occurs due to thermal expansion of pipes, and due to vibration induced from compressors, refrigerant flow, or forces applied from outside the refrigeration system.

1. ☐ Expansion joints have a "Z-bend" or a change in direction at areas of concerns.
2. ☐ Long straight runs of pipe include extra changes in direction to accommodate expansion

ASHRAE HVAC Systems and Equipment Handbook (Chapter 45 in the 2008 edition) provides guidelines for designing refrigerant piping expansion joints. The installed design must comply with local codes and regulations.

4.3.5. PIPE SUPPORTS

Pipe supports are used for all refrigerant piping. Most of the pipes in the field are insulated, except the gas cooler lines.

☐ Insulated pipes should use saddles to avoid tearing.

☐ The saddle can be metal or PVC (Poly Vinyl Chloride).

☐ The saddle should have a smooth surface and the length of the saddle should be almost three times the diameter of the pipe with its insulation.

☐ The saddle should be in contact with 1/3 of the insulated pipe perimeter.

☐ Air gaps should be maintained between insulated pipes to avoid sweating.

☐ No support should have direct contact with the pipes to avoid heat gain and water seepage due to condensation.

☐ Saddles are also used for underground piping, where insulated pipes are routed through trenches.

☐ Metal clamps are to be avoided as pipe support as they promote heat gain and vapor condensation.

4.3.6. PIPING JOINTS

Figure 4-3. Piping support

The following discusses common types of joints commonly found in refrigeration units. It includes brazed, threaded, and flared joints.

Brazed Joints

Kysor Warren Epta US recommends using brazed joints.

Copper joints are brazed with minimum 15% silver brazing alloy (filler) and for dissimilar metals use minimum 45% silver brazing alloy (filler). While brazing, pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed.

> **NOTE**
>
> Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent the entry of air and moisture.

The following are some considerations for brazed joints. When in doubt, consult the technical manual or legend sheet.

☐ Suction and liquid lines are not taped or soldered together. Instead, use a heat exchanger.

☐ There is no flux present on the soldered joint.

☐ P traps are at the bottom of suction line risers that are 4 feet or longer.

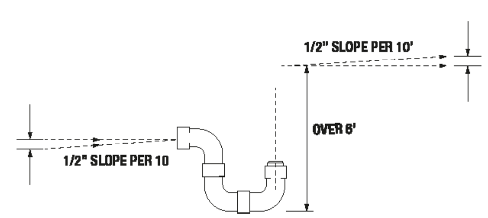


Figure 4-4. Slopes for suction Lines

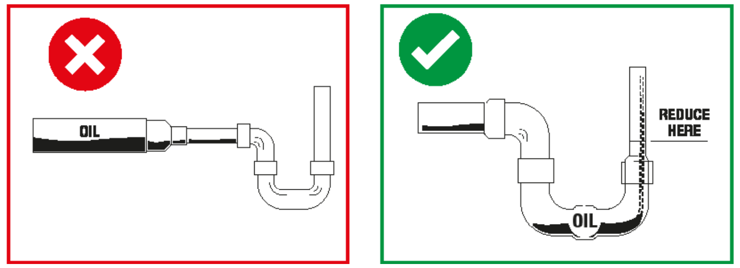


Figure 4-5. Placement of Oil Traps on Suction Lines

☐ Double “P” traps are present for each 20-foot of riser.

☐ Use long radius ells and avoid 45° ells.

☐ Provide expansion loops in suction lines on systems with hot gas defrost

☐ Flux only the male portion of the connection line never the female portion. Remove the flux after brazing.

NOTE

A suction line trap must be installed at the point where piping changes the direction of refrigerant flow from any horizontal run to an upward vertical run.

Piping should not disrupt or restrict refrigerant flow. Allowing sufficient “play” in the piping system and reducing abrupt changes in refrigerant direction reduces internal stresses and pressure drops. Short radius elbows for example, should be avoided if possible because they increase stress on the piping and cause the refrigerant to lose pressure.

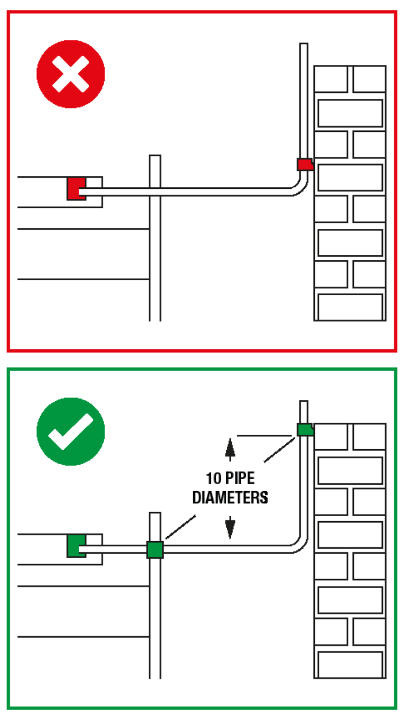


Figure 4-6. Corners support illustration.

Contractors install piping supports based on the plans and industrial standards. Straight lengths of piping for example below, must be supported at each end and have additional supports not more than every 8 feet. Cushioned clamps and pipe supports should be used to prevent contact between pipes.

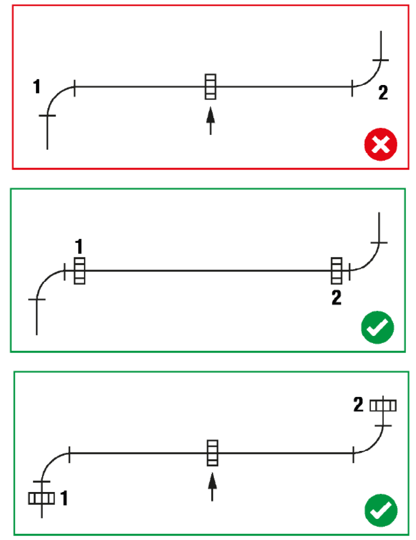


Figure 4-7. Corners support illustration.

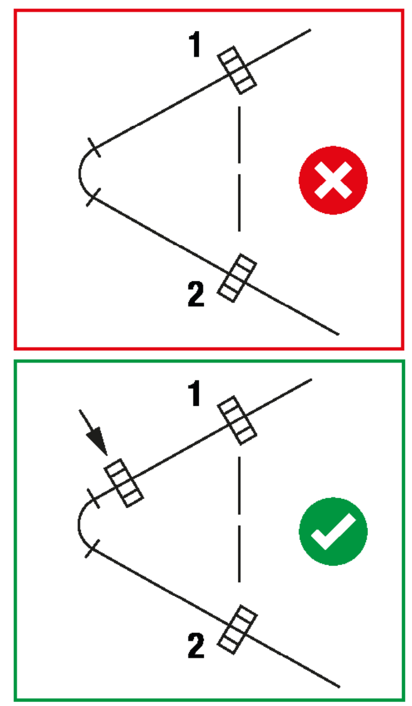


Figure 4-8. Corners must be supported and cannot be left free to pivot around 1-2

Threaded Joints

Threaded joints have a greater likelihood of leaking than brazed joints. When using threaded joints in CO_2 systems, high pressure sealant is required. **For low and IM pressure, Loctite 545** is recommended for sealing threaded joints. For **high operation pressure** (above 652 psig), the threads are wrapped 3-4 times with Teflon tape; then **Loctite 277 Threadlocker** is applied over the tape before the threads are engaged.

Flared Joints

Kysor Warren Epta US does not recommend flare joints.

4.4 TESTING AND 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

☐ 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 OR BYPASS ALL DEFROST HEATERS

4. OPEN VALVES

☐ Ball valves to circuits, branches, satellites, heat reclaim, receiver, etc.

☐ De-energize the solenoid valves (which are normally open).

5. CHECK FOR LEAKS

☐ System pressure is brought to a minimum of 300 psig.

☐ Verify pressurization at multiple system access points.

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

☐ System is depressurized

☐ Evacuation pump and sensors working properly

☐ No contaminates are introduced

☐ Evacuation pump is connected to 3 points on rack

☐ Copper lines or approved vacuum hoses are required

☐ Vacuum pump is rated at 8 cfm as a minimum and can reach all parts of the system.

☐ Vacuum pump oil as recommended by manufacturer (use new and clean oil)

☐ Electrical connections are secure and uninterrupted

☐ There are no leaks at the vacuum pump connections.

Lines and Valves

☐ Copper lines or suitable hoses are used.

☐ Packless valves are used

☐ All schrader valve caps are tightened and checked.

☐ All access valve caps are tightened

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

7. TRIPLE EVACUATION PROCEDURE

1st Evacuation

☐ Pull a system vacuum down to at least 1,000 microns (+/- 50 microns) and close the vacuum header valves.

☐ If system cannot maintain a vacuum and returns to atmospheric pressure, check and correct leak(s) as previously described

☐ When system maintains a 1,000 micron vacuum for 30 minutes, break the vacuum with dry nitrogen to a pressure of 2 psi

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.

☐ Add oil to the compressors, oil separator and oil reservoirs, if equipped before starting compressors

3rd Evacuation

☐ Pull a third vacuum to a minimum of 500 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 500 micron vacuum holds for 24 hours with a maximum drift of 100 microns over the 24 hour period.

☐ Break the vacuum: see the process on 5.3 Initial Charging

4.5. INSULATION

Insulation pipes provide:

- Reduces heat transfer to the refrigerant and fluid lines
- Prevents condensation and ice formations on pipe surfaces
- Minimizes pipe corrosion

Insulation should be installed according to local building codes, customer specifications, and manufacturer specifications. ASHRAE 90.1 provides guidelines for insulation for commercial refrigeration.

Warm pipes used for heat rejection usually do not require insulation unless insulation is specified to enhance reclaiming waste heat for use elsewhere (such as hot water and comfort).

Insulation Thickness

Guidelines are shown for insulation thickness. Refer to customer specifications when available.

Normal or Severe Conditions

Insulation material is typically rated for either normal conditions (indoor applications), or severe conditions (outdoor applications). Insulation designed for severe conditions should also be used near exterior openings, non-conditioned areas, or areas with high temperatures and humidity.

Materials

Kysor Warren Epta US recommends closed-cell elastomeric foam material for insulation. Insulation manufacturers provide detailed guidelines and training programs for installing insulation Table 4-4 lists two suppliers

Armacell LLC 7600 Oakwood St. Ext. - Mebane, NC 27302 919-304-3846 / www.armacell.com	
K-Flex 100 Nomaco Drive - Youngsville, NC 27596 800-765-6475 / www.kflexusa.com	

Table 4-4. Recommended Elastomeric Insulation Suppliers

Insulation Thickness				
	Pipe Size	Combined Liquid	LT Suction	MT Suction
Normal Ambient Conditions +85°F Dry Bulb 70% RH	Up to 1/2"	3/4"	3/4"	3/4"
	5/8" to 2-1/8"	3/4"	1"	3/4"
Severe Ambient Conditions +90°F Dry Bulb 80% RH	Up to 1-1/8"	1"	1-1/2"	1"
	1-3/8" to 2-1/8"	N/A	1-1/2"	N/A

Table 4-5. Recommended Insulation Thickness

Installation Notes

- All valves, controls, and fittings on refrigerant fluid lines should be insulated so as to allow easy access for component servicing.
- Components should also be insulated to minimize air pockets or voids, which can collect moisture and cause corrosion.
- Insulation manufacturers provide detailed guidelines and training programs for installing insulation.

4.6. LABELING REQUIREMENTS

Labelling refrigerant piping assists personnel in the identification and location of parts of the system. Refer to **ANSI/ASME Standard A13.1-81**, "Scheme for the Identification of Piping Systems", for labelling requirements, standards, and placement.

All refrigerant piping should be labeled with arrows indicating direction of flow (see Figure 4-9).

In addition, some piping should provide labels to show (see Figure 4-6):

- Fluid type (i.e., Carbon Dioxide)
- Origin of Flow
- Typical Operating Pressure

Table 4-5 provides information on two label suppliers.

Brimar Industries 64 Outwater Lane - Garfield, NJ 07026 800-274-6271 / www.brimar.com	
Seton 20 Thompson Road - Branford, CT 06405 800-243-6624 / www.seton.com	

Table 4-6 Pipe label suppliers

4.7. ELECTRICAL

Details of the system electrical components and requirements are found in the project Schedule / Legend of Equipment Load and Electrical Requirements. Table 4-7 lists the following power requirements:

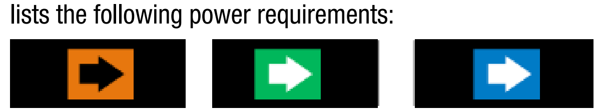


Figure 4-5 Example labels on piping

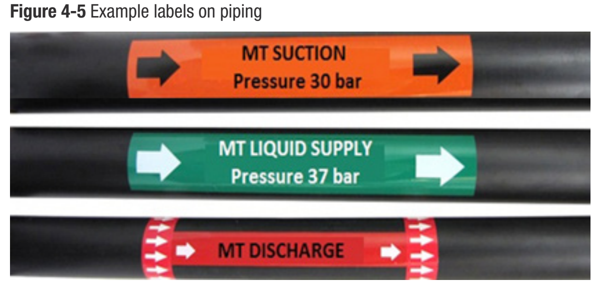


Figure 4-9. Other examples of labels on piping

Components	VAC Requirement
Compressors	208/60/3, 460/60/3, or 575/60/3
Controls	208/60/1
Electric Defrost	208/60/3, 208/60/1

Table 4-7. Electric Power Requirements

5

SYSTEM OPERATION

KYSOR WARREN

5. SYSTEM OPERATION

Once the system installation is complete, all piping has been evacuated to specification, and all equipment is powered-up and ready to operate; the initial startup of the CO2 Transcritical System is done with the following steps – the numbers correspond to the subsections:

5.1. INITIATE SYSTEM POWER

5.2. EVAPORATOR TEMPERATURE CONTROL

5.3. CO2 INITIAL CHARGING

5.3.1. Required Equipment and Material

5.3.2. Oil Charge

5.3.3. Charging CO2 Vapor

5.4. START COMPRESSORS

5.4.1. Start ACU (optional)

5.4.2. Controls/Instrumentation Check

5.4.3. Liquid CO2 Charge to Flash Tank

5.4.4. Start MT compressors

5.4.5. Pull Down MT Cases & Walk-ins

5.4.6. Start LT compressors

5.4.7. Pull down LT Cases & Walk-ins

5.5. DEFROST SETUP

5.6. WALK-IN DOOR SWITCHES

5.1. INITIATE SYSTEM POWER

Prior to charging the system or starting compressors, confirm that

- ☐ 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

- ☐ Initial checks for equipment has been completed according to manufacturer's recommendations
- ☐ Control System is installed and programmed according the System SOO setpoints
- ☐ Controls, gauges, and thermometers are displaying temperatures and pressures (Check values expected without refrigeration system operating)

5.2. 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 the "ice bath" method, or using a calibrated thermometer.

> **NOTE**
> Some adjustment may be required on controller settings.

5.3. CO2 INITIAL CHARGING

5.3.1. REQUIRED EQUIPMENT AND MATERIALS

The following materials are needed to charge the system. The refrigeration installation contractor is responsible for having these materials. See information on CO2 grades and suppliers and suppliers discussed in Section 2.

- ☐ CO2 Vapor Cylinders

  Instrument or Coleman Grade CO2 vapor to break vacuum and pressurize the system to 150 psig. Tanks are stored at room temperature; dispensing cold refrigerant is limited.

- ☐ CO2 Liquid Cylinders (w/dip tube)

  Instrument or Coleman Grade CO2 for remainder of charge – reference refrigeration legend for estimated charge

- ☐ Charging Hoses
  - 3/8" hose recommended for faster charging
  - Rated for 1740 psig working pressure
- ☐ Manifold Gauges

  Rated for 900 psig working pressure

- ☐ CGA-320 Adapter Fitting

  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.

- ☐ Filter/Dryer

  Provide filter/dryer in filed charge line. Change filter/dryer about every 600lb. CO2

- ☐ Refrigerant Scale

  Measures the quantity and rate of CO2 charging from the cylinders. The scale needs to be rugged enough for the weight and handling of the cylinders.

- ☐ POE Oil

  To fill oil reservoir and compressor crankcases; Oil should be purchased directly from the CO2 Compressor manufacturer.

  - BITZER CO2 compressors use POE oil – BSE85K
  - Emerson Copeland CO2 Compressors use POE Oil – EMKARATE RL68HB
- ☐ Manual Oil Pump

5.3.2. OIL CHARGE (NEED TO BE DONE BETWEEN 2ND AND 3RD EVACUATION)

Oil Charge to the Oil Separator

- ☐ Confirm that oil is compatible with compressors
- ☐ Close valves to isolate oil separator
- ☐ Open oil separator
- ☐ Fill the separator with based on manufacturers recommended

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

Oil Charge to Compressors

- ☐ Oil to compressor based on the manufacturers recommended.
- ☐ Confirm that the compressor crankcase heaters are energized for 24h before start up

> **NOTE**
> Crankcase heater must be operating to warm the oil prior to starting the compressor.

5.3.3. CHARGE THE CO2 VAPOR

The vacuum is broken with a vapor CO2 charge only. Liquid CO2 will form into solids potentially causing damage to the equipment.

- ☐ Break the vacuum with vapor CO2 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 CO2 to 150 psig
- ☐ Check that any rack gauges and control pressures read 150 psig

> Gauges or sensors that are reading less than 150 psig indicate that some valves might be closed, or faulty pressure transducer
>
> Gauges or sensors reading greater than 150 psig indicate faulty pressure transducer reading

> **NOTE**
> For CO2, saturation temperature = -34°F @ 150 psig

5.4. START COMPRESSORS

5.4.1. START AUXILIARY CONDENSING UNIT (ACU) (OPTIONAL)

This applies to systems equipped with an Auxiliary Condensing Unit (ACU). To prevent loss of CO2 charge at the relief valves, further charging should only be performed when the operation of the ACU has been confirmed. The ACU is activated by the ACU Pressure Control on the flash tank. When the flash tank pressure rises to the ACU setpoint, this control energizes the liquid line solenoid to the ACU heat exchanger.

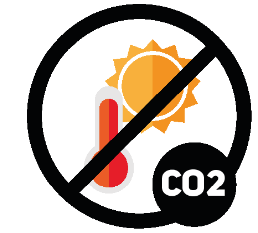
VAPOR CHARGING

As vapor is drawn from the CO2 cylinders, pressure and temperature inside the cylinder will decrease. Frosting on the bottom exterior of the cylinder is evidence that some CO2 liquid evaporated inside. The reduction in pressure also causes a slower flow rate of vapor into the system. Once the flow from the cylinder has slowed to a low level, the cold cylinder should be disconnected and allowed to warm (see Warming CO2 Cylinders below). 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.

WARMING CO2 CYLINDERS

CO2 Cylinders can be warmed by placing them in a warm place, in direct sunlight, and by directing airflow at them using an un-heated fan. DO NOT use direct heating on CO2 cylinders to raise their pressure/temperature.

The Compressed Gas Association provides additional guidelines for the safe use and handling of the CO2 cylinders. For more information, contact: Compressed Gas Association / 703-788-2700 / www.cganet.com



NOTE

For systems without an ACU, LT/MT loads should be gradually bought online; and system operation and controls are validated prior to adding further charge under guidance of experienced field contractor or field technician.

- ☐ 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

5.4.2. CONTROLS/INSTRUMENTATION CHECK

SOO (Sequence of Operation) is provided for individual systems. The SOO provides general information for programming of controls and various alarms.

Mechanical Pressure Switches

Confirm that mechanical switches are operating properly. All pressure controls should be adjusted until they actuate and it is verified that the desired result is achieved. The controls should then be set to their proper setpoints (reference SOO).

- ☐ MT and LT Compressor High Pressure Controls – reference SOO for setpoints
- ☐ Tag or Label preset MT and LT Mechanical High Pressure Cut-off Switches
- ☐ MT and LT Compressor and/or Suction Group Low Pressure Controls – reference SOO for setpoints
- ☐ Tag or Label preset MT and LT Mechanical Low Pressure Cut-off Switches
- ☐ ACU Pressure Control – 500 psig cut-in / 450 psig cut-out
- ☐ Tag or Label preset ACU Mechanical Control Switch – ACU optional

Pressure & Temperature Sensors

Check that all pressure and temperature sensors are calibrated and providing accurate readings at the controller

- ☐ Cases
- ☐ Gas Cooler Outlet
- ☐ Walk-ins
- ☐ Flash Tank
- ☐ Rack System (reference SOO)
- ☐ Oil Supply
- ☐ Gas Cooler (reference SOO)
- ☐ LT Suction
- ☐ MT Suction
- ☐ LT Discharge
- ☐ LT Discharge
- ☐ Heat Reclaim Outlet (if applicable)
- ☐ Parallel Suction (if applicable)
- ☐ Outside Air Temperature/Humidity
- ☐ Oil Separator Outlet Pressure (if applicable)
- ☐ Flash Tank Level Indicator (if applicable)

Digital Input Verification

Check that all digital inputs are reading open or closed as expected. Exercise each component as possible and verify the results at the proper input point.

- ☐ Phase Loss Monitor
- ☐ Compressor Proofs
- ☐ Compressor Fails
- ☐ VFD Faults
- ☐ Oil Separator Level Switch
- ☐ Flash Tank Level Switches

Relay Output Verification

All relay outputs should be exercised and the proper results verified.

- ☐ Compressor Runs
- ☐ VFD Bypasses (when provided)
- ☐ Oil Separator Dump Valve
- ☐ Hot Gas Dump Valve
- ☐ Liquid Injection Valve
- ☐ Gas Cooler Bypass Valve
- ☐ Subcooler Expansion Valve (Temperature and Pressure Control)
- ☐ Subcooler Expansion Valve (Superheat Control)

Analog Output Verification

All analog outputs should be exercised and proper results verified.

- ☐ MT1 Compressor Speed Reference
- ☐ Parallel Compressor Speed Reference (if applicable)
- ☐ LT1 Compressor Speed Reference (if applicable)
- ☐ Gas Cooler Fan Speed Reference
- ☐ High Pressure Regulator Valve (HPV)
- ☐ Flash Gas Bypass Valve (FGV)
- ☐ Heat Reclaim Regulator Valves (if applicable)

☐ **VFD Set-up Verification**

Verify all Control Setpoints.

- ☐ MT/LT/Parallel Suction Pressure Targets
- ☐ Gas Cooler Outlet Temperature Differential Target (Supercritical)
- ☐ Flash Gas Pressure Target
- ☐ Oil Separator Dump Valve
- ☐ Hot Gas Dump Valve
- ☐ Liquid Injection Valve
- ☐ Gas Cooler Bypass Valve
- ☐ Subcooler Expansion Valve (Temp Control)
- ☐ Subcooler Expansion Valve (Superheat Control)

Electrical Connections

Connections to the display cases and walk-in freezers have been completed and proper operation of lights, fans, and anti-sweat heaters has been established.

- ☐ Connections to the display cases and walk-in freezers are completed
- ☐ Verify the operation of lights
- ☐ Verify the operation of fans
- ☐ Verify the operation of anti-sweat heaters

5.4.3. LIQUID CO2 CHARGE TO FLASH TANK

Safety Precaution Note: Charging CO2 refrigerant increases pressure in the system. For systems with an ACU, check that backup power and Auxiliary Cooling Systems are working properly to maintain safe pressures in the event of power outage or abnormal conditions. Otherwise loss of charge and/or damage to equipment could occur.

- ☐ Close the main CO2 liquid line valve

  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
- ☐ 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
- ☐ Adjust the flow of CO2 refrigerant by adjusting the valve on the refrigerant tank
- ☐ Typical tanks should fully release in approximately 5 minutes (releasing CO2 refrigerant too quickly may cause some solids to form in the valves resulting in sputtering)
- ☐ 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 refrigerant 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.

5.4.4. START MT COMPRESSORS

NOTE

Groups of case piping circuits can be designated to start sequentially to allow easier troubleshooting during startup. A system controller is typically used to manage the operation of the various circuits.

- ☐ MT Compressors should already be powered on in “stand-by” mode
- ☐ Change panel switch for compressors from OFF to ON
- ☐ Turn on case controllers for the first section of MT loads to be started
- ☐ Slowly open main CO2 liquid line valve(s) to the MT loads

  When ACU is NOT present:
  - ☐ Open isolation valve between HPEV and Flash Tank
  - ☐ Open isolation valve between FGBV and Flash Tank
- ☐ MT compressors begin running and pulling down case pressures and temperatures.
- ☐ Add CO2 Liquid Charge to maintain the flash tank level just above first site glass (no more than 25%) after cases are running at operating temperatures.

5.4.5. PULL DOWN MT CASES & WALK-INS

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

5.4.6. START LT COMPRESSORS

☐ Open main CO2 liquid line valve(s) to the LT loads

☐ LT Compressors should already be powered on in "stand-by" mode

☐ Change panel switch for compressors from OFF 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 (see note below) after cases are running at operating temperatures.

NOTE
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.

5.4.7. 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

5.5. DEFROST OPERATION

The standard system defrost design is off cycle and electric defrost. Defrost should be programmed to operate with 10% to 20% of system load/capacity at a time. This ensures that the system has sufficient cooling capacity to maintain the temperature of the system while recovering after defrost periods. Defrosting CO2 evaporators is similar to conventional systems. Defrosting the evaporators is accomplished in three sequential stages, referred to as operating modes:

- Pumpdown Mode
- Heating Mode
- Drip Mode

The controller can be programmed to start and manage the defrost modes based on routine time periods, or based on temperature set-points.

NOTE
Reference the SOO for additional controller details.

1. **Pumpdown (10-12 minutes duration)**

   The controller initiates pumpdown mode, the first defrost stage. During this stage, the evaporator circuit (or evaporator) solenoid valve (or EEV) is closed preventing refrigerant from flowing to the evaporator(s). The evaporator fans run while any liquid CO2 refrigerant remaining in the evaporator continues to boil into vapor.

2. ☐ **Heating (45-60 minutes maximum)**

   After the pumpdown period, electric heaters are turned on to melt accumulated ice on the evaporators. Evaporator fans are always off during the heating stage. The heater power is typically terminated when the evaporator temperature reaches a temperature set-point. The set-point is based on a temperature sensor located at the center of case evaporators, or at the U bend on walk-ins. The heater may also be terminated based on a set maximum (fail safe) time period. Circuits with various size cases should also have a defrost Klixon and relay installed to individual smaller cases to avoid over-heating.

3. ☐ **Drip Mode (10 minutes)**

   After the heating stage is complete, condensate continues to drip off the evaporator to the drain of the case or walk-in. The heater and fans are off during this stage. After Drip mode, the system resumes normal operation, with the evaporator cooling the load back to the set temperature.

5.6. WALK-IN DOOR SWITCHES

Door switches should be installed to freezers (LT) only, and set to cut-off fans during door openings. Door switches are wired to the system controller where door openings are recorded. Extended door openings set an alarm at the controller.

6

MAINTENANCE AND **TROUBLESHOOTING**

MAINTENANCE AND TROUBLESHOOTING

6.1. GENERAL MAINTENANCE PROCEDURES

Proper maintenance is critical to long term reliability and efficiency. For more detailed maintenance procedures, refer to the maintenance schedule or requirements for the specific system. The following are some general maintenance procedures.

6.1.1. INITIAL STARTUP

Operators should be especially careful during initial startup procedures. The following are some recommended maintenance steps to take during initial startup.

☐ Change all filters and driers by end of first week of startup

☐ If filters are dirty, repeat in 7 days

After 90 days:

- ☐ Change the filter driers
- ☐ Remove the suction line filter core
- ☐ Replace oil coalescing media

Suction Filter

Replaceable core suction filters are supplied for all units. The flanged shell holds replaceable pleated filter elements suitable for installation in the suction line of refrigeration systems. In this way any contaminants left in the system at start-up can be removed before they circulate back to the compressor. The suction filters are shipped loose for field installation.

Pressure Relief Valves (PRVs)

If the system is de-energized, venting of the R744 through the pressure-regulating relief valves on the equipment can occur. In such cases, the system might need to be recharged with R744, but in any case, the pressure regulating relief valve(s) shall not be defeated or capped. The relief setting shall not be altered.

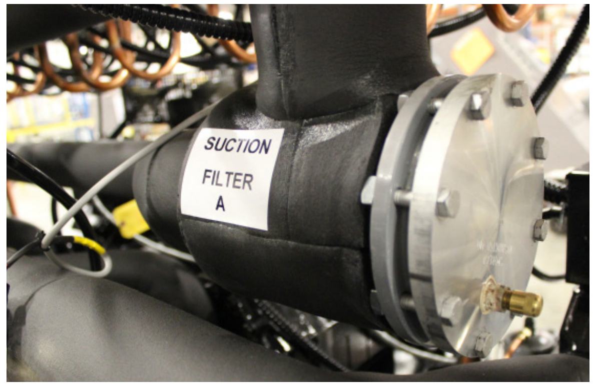


Figure 6-1. Suction Filter.

6.1.2 PUMP-DOWN AND RESTART SEQUENCE FOR SERVICE

Pumping-down the system for service:

1. Close liquid CO2 supply ball valve from flash tank (valves A01 & A02).
2. System starts to self-pump-down (MT pump-down pressure set point is 350 psig and LT pump-down pressure set point is 160 psig).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.
3. Turn OFF compressors using their switches on control panel.
4. Isolate flash tank. Close valves to FGBV (B1), Oil reservoir (L18), and from HPEV (A18).
5. Use change over valve (A12) on the flash tank (R2) to switch to 1305 psig psi pressure relief valve (D7) (systems with an AUX CDU there is no need to change the pressure relief valve).
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. High pressure in FGT above the max pressure set point (580 psig) will make the controller open the FGBV and close the HPEV.
5. Turn ON the switch for the lead MT compressor. 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.
6. Gradually open angle valve from HPEV (A18). Since controller is calling for close HPEV there should be no increase in flash tank pressure.
7. Gradually open the ball valve to FGBV (1BV). Initially barely cracked B1 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). Caution: Opening the ball valve fast can result in releasing refrigerant charge from MT suction PRV (E30).
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 (A12) on flash tank to switch to 650 psig pressure relief valve (R2)
11. Open the valve that connects flash tank to oil reservoir (L18).
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 (A1). 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 (A18, L18, B1, A1) and 650 psig PRV on flash tank is in service (R2).

6.1.2.1. PUMPING-DOWN THE SYSTEM FOR STANDBY (EXTENDED PERIOD)

1. Close liquid CO2 supply ball valve from flash tank (valves A10 & A12).
2. System starts to self-pump-down (MT pump-down pressure set point is 350 psig and LT pump-down pressure set point is 160 psig). Wait until there is no pressure rise in LT and MT suction. Pressure rise is in LT and MT suction is in the indication of liquid present in the system. When LT and MT compressors stays off for 10 minutes, continuously move to step 3.
3. You can leave the system standby at this point as long as there is a need for it. The system automatically maintain flash tank pressure. Compressors will come on if there is a need.
4. To start up the system, simply open liquid CO2 supply ball valve from flash tank (valves A10 & A12).

6.1.3. SCHEDULED MAINTENANCE

Table 6-1 shows the recommended inspection items for a scheduled maintenance program.

Action	Weekly	Monthly	Yearly
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.	☐	☐	☐
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.		☐	☐
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			☐

Table 6-1. Recommended Scheduled Maintenance

NOTE

The above information is provided only as a general guideline to aid servicing personnel and equipment owners in maintaining equipment.

NOTE

Actual service intervals may vary from the recommended due to variables in the actual equipment application, operating conditions, and environment.

Compressor Burnout Cleanup

The following is a recommended sequence to use in case of a motor burnout

- Determine the extent of the burnout. For mild burnouts where contamination has not spread through the system, it may be economical to save the refrigerant (see note after below).
- Replace all strainers and filter-driers.
- Install a replacement compressor and make a complete electrical check.
- Make sure the suction line adjacent to the compressor is clean. Replace the liquid line filter-drier (or replaceable cartridge) designed for "cleanup". (After 90 days, the suction line filter should be removed.)
- Install a burnout core in the liquid line shell.
- If the refrigerant is removed from the system, add charge as needed.
- Start the compressor.
- Record the pressure drop across the suction line filter and keep for reference.
- Replace the suction line filter-drier core(s) if the pressure drop becomes excessive. After 90 days, the suction line filter should be removed.

NOTE

The refrigeration charge can be saved if the system has service valves. A severe burnout exists if the oil is discolored, an acid odor is present and contamination products are found in the high and low side. With this condition, extreme caution should be exercised to avoid breathing the acid vapors and to prevent contaminated liquid from making contact with the skin. If needed, thoroughly clean and verify operation of system controls, such as expansion valves, solenoids, check valves, reversing valves, oil separators, suction accumulators, etc. In extreme cases, components may need to be replaced.

	AFTER 4 HOURS	Observe the system during the first 4 hours. Replace filter cores as often as required, until no further change in pressure drop is observed.
	AFTER 48 HOURS	After the system has been in operation for 48 hours, check the condition of the oil for acids. If the oil test indicates an acid condition, replace the liquid and suction line filter- driers.
	AFTER 2 WEEKS	Check the system again after approximately 2 weeks of operation. If the oil is still discolored, or checks acid, replace the liquid and suction line filter-driers. Cleanup is complete when the oil is clean, odor free, and is determined to be acceptable by testing for acids or other contaminants. Replace the suction line filter-drier with suction line filters cores to minimize suction line pressure drop and to provide maximum compressor protection.
	AFTER 90 DAYS	Suction Line filter should be removed

Table 6-2. Compressor Burn-out Time Line

One key benefit of a suction filter is its use in cleanup of a system after a burnout. Standard liquid cores can be installed in the shell to aid in the cleanup of acids and other contaminants from a motor burnout.

6.2. ALARMS

See the Sequence of Operation (SOO) for a summary of alarms.

6.3. COMMON MAINTENANCE ACTIONS

6.3.1. FREQUENT CAUSES FOR HIGH CO2 PRESSURE

Causes of High CO2 Pressure on MT or LT compressor suction:

- Non-condensable gases
- High evaporator load
- High store ambient conditions (temperature or humidity)
- LT compressor group stopped (LT compressor suction only)
- MT compressors tripped (MT compressor suction only)

6.3.2. EVACUATING NON-CONDENSABLE GASES

Non-condensable gases are prevented by:

- Following proper evacuation steps
- Purging refrigerant lines during charging process
- Ensuring that valves are never opened such that a vacuum is created in the piping.

6.3.3. PREPARATION FOR PIPING REPAIRS

Use the following steps for the maintenance of piping or for replacing in-line components:

1. Close upper isolation valves first to allow liquid to drain downward
2. Use CO2 Gas from a 200-300 psig cylinder to push remaining liquid into adjoining piping if needed.
3. Close isolation valves to cases and walk-in freezers and manually start a defrost cycle to boil remaining CO2 liquid from the evaporators
4. Continue to remove liquid keeping piping pressures above 100 psig
5. When all liquid is removed, vapor CO2 can be released safely through a hose to a well-ventilated space or outside the work area.
6. Keep CO2 gas cylinder attached to the system when possible with regulator set to 10 psig to prevent any air entering the piping.
7. Conduct repairs or replace parts
8. Before restarting the system, evacuate the piping according to customer specifications. (See section 0 Testing and Evacuation).
9. Break vacuum with CO2 vapor, and pressurize the piping to 150 psig.
10. Return isolation valves to the open (or normal operating) position.

6.3.4. SYSTEM SHUT DOWN

The CO2 system should be pumped down before turning off the rack to prevent loss of CO2 through the relief valves. Use the following steps to turn off the CO2 TC Booster Rack

LT Pumpdown: Close the LT liquid supply ball valve allowing the compressors to continue running, in order to pumpdown the CO2 refrigerant at the system LT side. CO2 refrigerant will flow to the flash tank.

MT Pumpdown: Close the main liquid supply valve at the outlet of the flash tank, and allow the compressors to continue running, in order to pumpdown the CO2 refrigerant at the system MT side. CO2 refrigerant will continue to flow to the flash tank. MT compressors will cycle off at the low suction pressure setpoint. The compressor crankcase heaters will automatically turn on as the compressors cycle off.

With ACU Option: As an option, systems are equipped with an ACU to maintain CO2 temperature and pressure to prevent venting CO2 refrigerant from the system. The ACU is set to a slightly higher operating pressure so it doesn't run during normal operation.

Without ACU Option: Systems without ACU are designed with a high pressure flash tank. For these systems, all refrigerant is pumped down during service, and isolated from the system by closing the FGT liquid lines. If the ACU is not operating, the system will eventually warm up and vent CO2 refrigerant

Refrigerant: CO2 refrigerant charge should be verified and possibly added to normal level after restarting the system

6.4. TROUBLESHOOTING

Refrigeration systems are complex and run constantly. Problems have to be quickly corrected or expensive produce will be ruined.

Troubleshooting is a logical and systematic search for the source of a problem in order to correct the problem and make the system operational again in a minimal amount of time.

When troubleshooting a system, it is important to have a systematic approach to collecting and analyzing data. Table 6-3 is an example of a general troubleshooting process.

NOTE

Table 6-3 is an example only. Operators should develop a troubleshooting methodology for their own specific equipment.

	PROBLEM	POSSIBLE CAUSES	POSSIBLE CORRECTIVE STEPS
COMPRESSOR	Compressor will not run	Main switch open	Close switch.
		Fuse blown	Check electrical circuits and motor winding for shorts or grounds.
			Investigate for possible overloading.
			Replace fuse after fault is corrected.
		Thermal overloads tripped	Overloads are automatically reset.
			Check line.
		Defective contactor or coil	Repair or replace.
		System shut down by safety devices	Determine type and cause of shut-down and correct it before resetting safety switch.
		No cooling required	None. Wait until calls for cooling.
		Liquid line solenoid will not open	Repair or replace coil.
		Motor electrical trouble	Check motor for open windings, short circuit or burn out.
		Loose wiring	Check all wire junctions. Tighten all terminal screws.
		Phase loss monitor inoperative	Refer to Phase Loss manual. Make sure 3 phases of power are supplied to module
	Compressor noisy or vibrating	Flooding of refrigerant into crankcase	Check setting of expansion valves.
		Improper piping support on suction or liquid line	Relocate, add or remove hangers.
		Worn compressor	Replace compressor.
		Scroll compressor rotation reversed	Rewire for phase change.
		Oil levels too high	Reset oil float and/or drain excess oil from system.
	Compressor thermal protector switch open	Operating beyond design conditions	Add components to bring conditions within acceptable limits (i.e., CPR)
		Discharge valve partially shut	Open discharge valve.
		Blown valve plate gasket	Replace gasket.
		Dirty condenser coil	Clean coil.
		Overcharged system	Reduce charge.
PRESSURE	High discharge pressure	Non-condensable gas in system	Remove the non-condensable gas.
		System overcharges with refrigerant	Remove excess.
		Discharge shutoff valve partially closed	Open valve.
		Fan not running	Check electrical circuit.
		HPEV stuck almost closed	Check HPEV opening in EMS.
		Dirty condenser coil	Clean.
	Low discharge pressure	Faulty condenser temperature regulation	Check gas cooler control operation.
		Suction shutoff valve partially closed	Open valve.
		Insufficient refrigerant in system	Check for leaks. Repair and add charge.
		Low suction pressure	See corrective steps for low suction pressure.
		Variable head pressure valve	Check valve setting.
	High suction pressure	Excessive load	Reduce load or add additional equipment.
		Expansion valve overfeeding	Check remote bulb. Regulate superheat.
	Low suction pressure	Lack of refrigerant	1. Check for leaks. Repair and add charge.
		2. Evaporator dirty or iced	2. Clean.
		3. Clogged liquid line filter drier	3. Replace cartridge(s).
		4. Clogged suction line or suction gas strainers	4. Clean strainers.
		5. Expansion valve malfunctioning	5. Check and reset for proper superheat.
		Condensing temperature too low	Check means for regulating condensing temperature.
		Improper TXV	Check for proper sizing.
OIL	Little or no oil pressure solenoid valve operation	Clogged suction oil strainer	Clean.
		Excessive liquid in crankcase	Check crankcase heater.
		Low oil pressure safety switch defective	Reset expansion line.
		Worn oil pump	Replace.
		Oil pump reversing gear stuck in wrong position	Reverse direction of compressor rotation. Replace compressor.
		Worn bearings. Low oil level	Add oil and/or through defrost.
		Loose fitting on oil lines	Check and tighten system.
		Pump housing gasket leaks	Replace gasket.
	Compressor loses oil	Lack of refrigerant	Check for leaks and repair. Add refrigerant.
		Excessive compression ring blow by	Replace compressor.
		Refrigerant flood back	Maintain proper superheat at compressor.
		Improper piping or traps	Correct piping.

Table 6-3. Example troubleshooting Table

7

WARRANTY AND MANUAL DISCLAIMER

STANDARD WARRANTY AND MANUAL DISCLAIMER

7.1. STANDARD WARRANTY

This appendix contains the KWs standard warranty for its products and a disclaimer for this manual.

Seller warrants to its direct purchasers that Products, including Service Parts, shall be of a merchantable quality, free of defects in material or workmanship, under normal use and service for a period of one (1) year from date of original equipment start-up, or eighteen (18) months from date of shipment by Seller, whichever first occurs. This warranty runs to only the original purchaser of equipment or part. Any Products covered by this warranty found to Seller's satisfaction to be defective upon examination at Seller's factory will at Seller's option, be repaired or replaced and returned to Buyer via lowest common carrier FOB seller's point of shipment. This is buyer's sole and exclusive remedy and, except as provided in the next sentence, seller's sole and exclusive liability in connection with the warranty. Or Seller may at its option grant Buyer a credit for the purchase price of the defective Product. Buyer must prepay all costs for transportation of Products to Seller's factory.

Seller shall have no liability for expenses incurred for repairs made by Buyer except by prior, written authorization. Any claim under this warranty shall be made to Seller in writing within the warranty period above, otherwise such claim shall be deemed waived. Seller shall have no warranty obligation whatsoever if its products have been subjected to alteration, misuse, negligence, free chemicals in system, corrosive atmosphere, accident, or if operation is contrary to Seller's or manufacturer's recommendations, or if the serial number has been altered, defaced, or removed.

This warranty is in lieu of all other warranties, expressed, implied or statutory, including, but not limited to any warranty of merchantability or fitness, and all other obligations or liabilities of seller are hereby disclaimed.

WARRANTY NOTES

This equipment is designed to operate properly and produce rated capacity when installed in accordance with accepted industry standards. Failure to meet the following conditions may result in voiding of the system warranty:

1. System piping must be installed following industry standards for good piping practices (see details later in this document).
2. Inert gas (dry nitrogen) must be charged into piping during welding.
3. System must be thoroughly leak checked and evacuated before initial charging. High vacuum gauge capable of reading microns is mandatory--Dials indicating pressure gauges are not acceptable.
4. Power supply to system must meet the following conditions:

- Voltage for 208/230 not less than 195 volts or more than 253 volts.
- All other voltages must not exceed +/- 10% of nameplate ratings.
- Phase imbalance not to exceed 2%.

5. All controls and safety switch circuits properly connected per wiring diagram.
6. Factory installed wiring must not be changed without written factory approval.

THIS WARRANTY SHALL NOT APPLY:

1. BULBS: Light bulbs, fluorescent lamp tubes and LEDs are not covered by any warranty for length of life or for any type of breakage.
2. To the condensing unit used with refrigerated equipment unless same was sold and shipped by Seller
3. When this equipment or any part thereof is damaged by accident, fire, flood act of God, alteration, abuse, misuse, tampering, when the original model and serial number plate has been altered, defaced, or removed or used other than the recommended application by Seller.
4. When this equipment or any part thereof is subject to operation on low, high or improper voltages. Low and high voltage is defined as more than a 5% drop below or 10% higher than name plate voltage ratings.

NOTE

Proper field supply voltage to the equipment is the responsibility of the owner (end user).

5. When this equipment or any part thereof is damaged, or when operation is impaired, due to failure to follow installation manual.

NOTE

Proper field supply voltage to the equipment is the responsibility of the owner (end user).

6. To equipment with final destinations unknown to seller as indicated on the original sales order.
7. To labor cost for repair or replacement of parts.
8. To special or expedited freight or shipping charges or to customs duties to any country.
9. If the Warranty holder fails to comply with all the provisions, terms and conditions of this Warranty.
10. Parts replaced under this Warranty are warranted only through the remainder of the original Warranty.
11. Extended Service Agreements are provided by a third party not affiliated with Seller. The services provided by the third party are subject to the terms and conditions of the Extended Service Agreements and Seller is not responsible for those services or the third party's performance of its obligations.

It is expressly understood and agreed that seller shall not be liable to buyer, or any customer of buyer, for indirect, special, incidental, consequential or punitive damages, including loss of profits, additional labor costs, loss of refrigerants or food product, or any injury to person or property caused by defective material or parts or for any delay or misperformance in the performance due to causes beyond its control or for any expenses incurred by reason of the use or misuse by buyer or third parties of the products. Seller's maximum liability for direct damages is limited to the amo"unt paid by the buyer for the particular item of equipment or part involved.

NOTE

In the constant effort to improve our products, we reserve the right to change at any time specifications, design, or prices without incurring obligation.

COMPRESSOR WARRANTY

Compressor replacements or exchanges shall be made through the nearest authorized wholesaler of the compressor manufacturer (not at Seller's factory) and no freight shall be allowed for transportation of the compressor to and from the wholesaler. The replacement compressor shall be identical to the model of the compressor being replaced

Additional charges which may be incurred throughout the substitution of other than identical replacements are not covered by this warranty. An optional, non-assignable, three (3) or four (4) year extended compressor warranty may be purchased within the boundaries of the United States of America, its territories and possessions, and Canada. With this extended compressor warranty, replacements are administered by an authorized compressor distributor only. Replacements within the first year of the warranty are available through the distributor, the second through fifth years, the purchaser must submit a proof-of-purchase of a compressor and supply it to N|vru Zduuhq Hswd XV Warranty Claims for reimbursement.

PARTS WARRANTY POLICY

The following procedures are in accordance with the N|vru Zduuhq Hswd XV standard one-year warranty, which covers any part to be free of defects under normal use and service for one year from the date of installation. (Not to exceed one year and 30 days from the date of original shipment from the factory.)

In Warranty/Non-Warranty Parts Replacement

When ordering Warranty replacement part(s), the following information must be furnished to the Parts Department via phone, or e-mail with purchase orders provided by Fax or e-mail only.

1. Full name and address of Company
2. Name and phone number of person ordering parts
3. Model number
4. Serial number
5. Factory order number
6. Description of parts desired
7. Original date of installation
8. Reason for replacement
9. Complete shipping address
10. Purchase order number

If the order is for a replacement still in warranty a Purchase Order Number will be required from the contractor placing the order. We will then issue a Return Material Authorization Tag (RMA) that will be sent to the firm or contractor who has ordered the part.

NOTE

All warranty replacements are shipped pre-paid fob shipping point. The warranty in effect for parts does not cover the cost of special freight terms – i.E. Ups next day, air freight, etc.

Warranty of Replacement Parts

Parts will be covered for the balance of the manufacturer's standard equipment warranty or 90 days from the date of shipment of the replacement part, whichever is longer.

If the order is for a replacement still in warranty a Purchase Order Number will be required from the contractor placing the order. We will then issue a Return Material Authorization Tag (RMA) that will be sent to the firm or contractor who has ordered the part.

NOTE

All warranty replacements are shipped pre-paid fob shipping point. The warranty in effect for parts does not cover the cost of special freight terms – i.E. Ups next day, air freight, etc.

Purchase Parts Locally

If you require an emergency Warranty replacement and you have to purchase the parts from a local supply house,

Kysor Warren Epta US will accept the return of the original part for replacement only. Should the locally purchased part(s) fail, it must be returned to the local supplier for replacement, repair or credit.

Return Authorization Procedure

When in-warranty replacement parts are shipped with the service order stating "warranty replacement, return replaced material within (45) forty-five days of shipping date or invoice will be rendered and payable", return is required. Credits will not be issued for parts returned after (45) forty-five days.

WORK AUTHORIZATION PROCESS FOR WARRANTY LABOR

All warranty labor claims must be approved in advance be an authorized Kysor Warren Epta US associate. Note: Only Technical Support associates and company officers are authorized to approve warranty labor. If labor is approved, the payee will be issued a written work authorization. All invoices submitted without a written work authorization are subject to denial. The following information is required before the issuance of a written work authorization:

- Store name
- Store address
- Model number (all involved), Serial number (all involved)
- Complete description of issues and corrections to be made
- A "Not to exceed" estimate for repairs

In case of after hour's emergency, you must contact the Technical Support Department at the beginning of the next business day.

Phone (800) 866-5596. Same info as above is still required.

The written work authorizations must be included with all invoices. Only written authorizations will be considered. E-mail approvals from authorized Kysor Warren Epta US associates are approved and should be included with invoices.

All invoices containing warranty parts not obtained from Kysor Warren Epta US Service Parts Department must be accompanied by the wholesaler's invoice for reimbursement or will be replaced through the Kysor Warren Epta US Service Parts Department. (Kysor Warren Epta US will pay only wholesale cost of parts if not supplied by Kysor Warren Epta US). All defective parts must be returned to Kysor Warren Epta US if so requested. (See Parts Warranty Policy)

Labor to change DOA compressors will be paid only with a teardown report from the compressor manufacturer, submitted with the invoice. (Note: Compressor must be factory defective as described in teardown report, before labor will be paid). Teardown reports have to be requested at the time of warranty exchange from an authorized wholesaler.

All model and serial numbers must be included on your invoice, (for all equipment serviced). For compressor warranty, the model and serial number of the unit the compressor was located and the model and serial number of the compressors – both old and new – must be included.

All invoices must be billed to Kysor Warren Epta US first party. Kysor Warren Epta US will not pay third party invoices. Emailed invoices and scans of backup are preferred and may speed processing.

Invoices submitted after 30 days from date when work was done will be subject to denial. Invoices submitted after 60 days from the date when work was done will be denied.

If you receive a notice requesting more information, (i.e. model, serial number, etc.), you will have an additional 30 days to respond. If a response is not received within 30 days, the invoice will be denied.

All warranties of the equipment are subject to standard manufacturer's warranty and terms and conditions of the sale. Any exception to the standard warranty policies must be specifically agreed to in writing by Kysor Warren Epta US prior to the date of sale.

All invoices must be billed to Nysor Warren Epta US, Attn: Technical Support Coordinator, 5201 Transport Boulevard, Columbus, GA 31907-8944. Phone (800) 866-5596.

Labor to replace parts damaged in transit (shipping damage) must be noted on the shipping bill before any labor charges will be considered for payment.

No warranties - This Manual is provided "as is" without any representations or warranties, express or implied. Kysor Warren Epta US makes no representations or warranties in relation to this Manual or the information and materials provided herein. Although we make a reasonable effort to include accurate and up to date information, without prejudice to the generality of this paragraph, Kysor Warren Epta US does not warrant that the information in this Manual is complete, true, accurate or non-misleading. The Kysor Warren Epta US CO2 System Manual is provided solely for informational purposes. You should not act upon information without consulting Kysor Warren Epta US, a distributor, subsidiary or appropriate professional.

Limitations of liability - Kysor Warren Epta US will not be liable to you (whether under the law of contract, the law of torts or otherwise) in relation to the contents of, or use of, or otherwise in connection with, this Manual:

- to the extent that this Manual is provided free-of-charge, for any direct loss;
- for any indirect, special or consequential loss; or
- for any business losses, loss of revenue, income, profits or anticipated savings, loss of contracts or business relationships, or loss of reputation or goodwill.

These limitations of liability apply even if Kysor Warren Epta US has been expressly advised of the potential loss.

NOTE

Installation and maintenance to be performed only by qualified personnel whoare familiar with local codes and regulations, and experienced with this type of equipment. Sharp edges and coil surfaces are a potential injury hazard. Avoid contact with them.

WARNING

There may be more than one source of electrical current in this unit. do not service before disconnecting all power supplies.

WARNING

All pertinent electrical codes and regulations must be strictly followed.any deviations from these requirements will be strictly the responsibility of the installer.

8 DATA, DEFINITIONS AND ACRONYMS

8.1. DATA

Subsection 8.1 contains the following data-related information:

- Typical dimensions of CO2 transcritical booster racks
- Example Piping Diagram
- CO2 pressure/temperature charts
- Temperature and pressure conversion charts

8.1.1. TYPICAL DIMENSIONS FOR CO2 TRANSCRITICAL BOOSTER RACKS

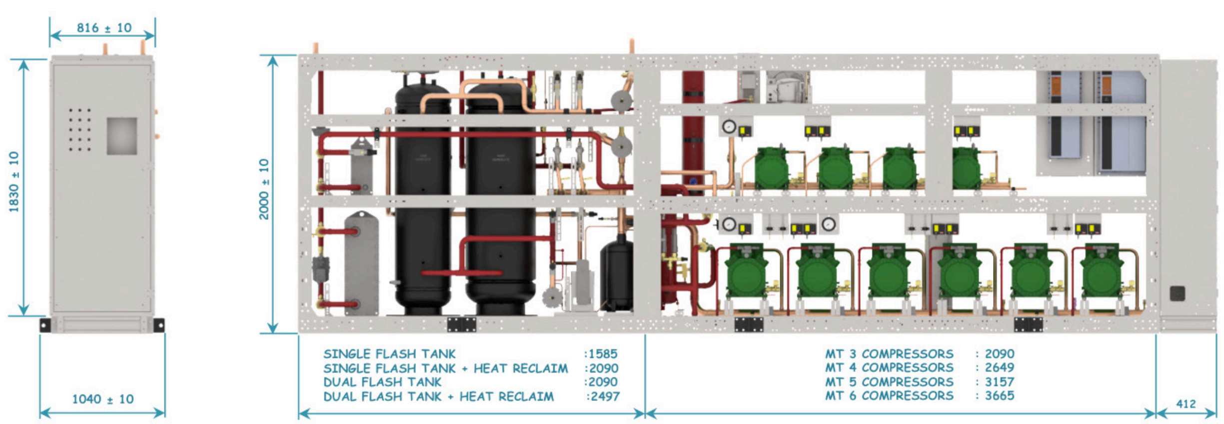


Figure 8-1. Global envelope for 1000mm

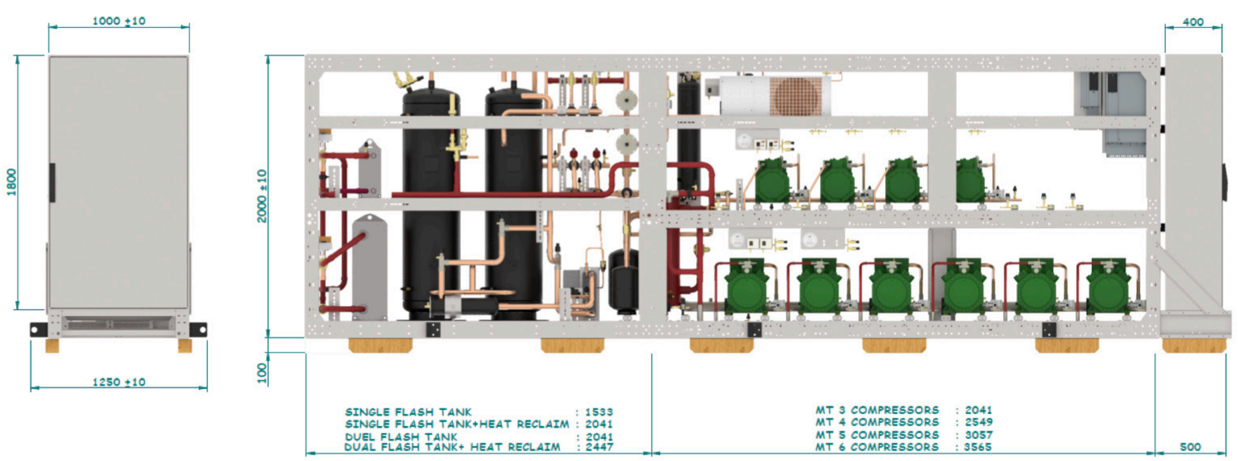


Figure 8-2. Global envelope for 800mm

8.1.2. EXAMPLE PIPING DIAGRAM

Figure 8-3 displays an example piping diagram for a CO2 transcritical booster refrigeration system. Actual systems will be different in detail but should have the same general features.

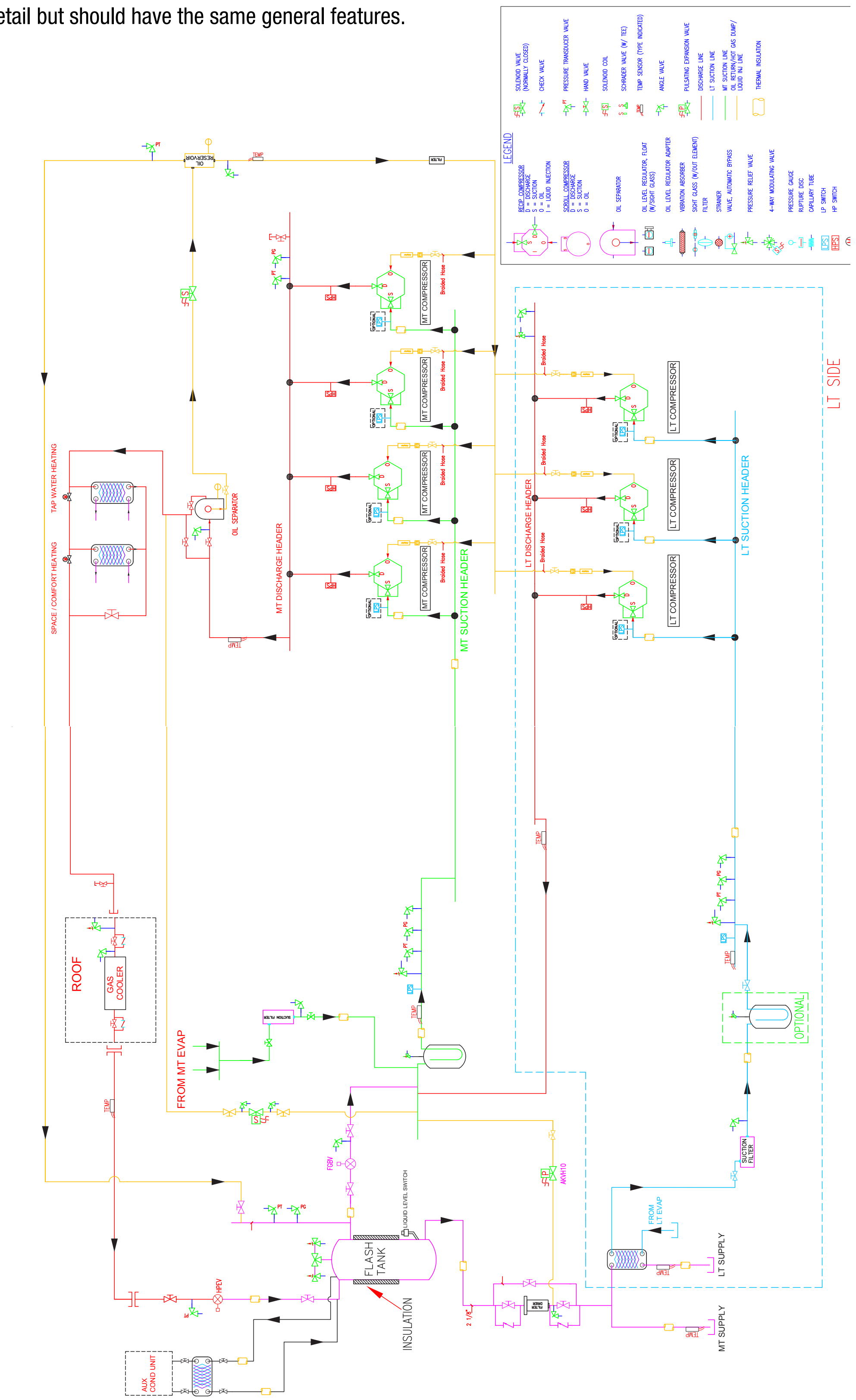


Figure 8-3. Example Piping Diagram

8.1.3. PRESSURE-TEMPERATURE CHART FOR CO2 (R744)

Below (Table 8-1) is the pressure-temperature chart for R744.

Temperature		Pressure	
(°C)	(°F)	(Bar-abs)	(psig)
-50.0	-58.0	6.8	84
-49.0	-56.2	7.1	88
-48.0	-54.4	7.4	93
-47.0	-52.6	7.7	97
-46.0	-50.8	8.0	101
-45.0	-49.0	8.3	106
-44.0	-47.2	8.6	111
-43.0	-45.4	9.0	116
-42.0	-43.6	9.3	121
-41.0	-41.8	9.7	126
-40.0	-40.0	10.0	131
-39.0	-38.2	10.4	136
-38.0	-36.4	10.8	142
-37.0	-34.6	11.2	148
-36.0	-32.8	11.6	154
-35.0	-31.0	12.0	160
-34.0	-29.2	12.5	166
-33.0	-27.4	12.9	172
-32.0	-25.6	13.3	179
-31.0	-23.8	13.8	185
-30.0	-22.0	14.3	192
-29.0	-20.2	14.8	199
-28.0	-18.4	15.3	207
-27.0	-16.6	15.8	214
-26.0	-14.8	16.3	222
-25.0	-13.0	16.8	229
-24.0	-11.2	17.4	237
-23.0	-9.4	17.9	245
-22.0	-7.6	18.5	254
-21.0	-5.8	19.1	262
-20.0	-4.0	19.7	271
-19.0	-2.2	20.3	280
-18.0	-0.4	20.9	289
-17.0	1.4	21.6	298
-16.0	3.2	22.2	308
-15.0	5.0	22.9	317
-14.0	6.8	23.6	327
-13.0	8.6	24.3	338
-12.0	10.4	25.0	348
-11.0	12.2	25.7	359
-10.0	14.0	26.5	369

Temperature		Pressure	
(°C)	(°F)	(Bar-abs)	(psig)
-9.0	15.8	27.2	380
-8.0	17.6	28.0	392
-7.0	19.4	28.8	403
-6.0	21.2	29.6	415
-5.0	23.0	30.5	427
-4.0	24.8	31.3	439
-3.0	26.6	32.2	452
-2.0	28.4	33.0	464
-1.0	30.2	33.9	477
0.0	32.0	34.9	491
1.0	33.8	35.8	504
2.0	35.6	36.7	518
3.0	37.4	37.7	532
4.0	39.2	38.7	546
5.0	41.0	39.7	561
6.0	42.8	40.7	576
7.0	44.6	41.8	591
8.0	46.4	42.8	606
9.0	48.2	43.9	622
10.0	50.0	45.0	638
11.0	51.8	46.1	654
12.0	53.6	47.3	671
13.0	55.4	48.5	688
14.0	57.2	49.7	705
15.0	59.0	50.9	723
16.0	60.8	52.1	741
17.0	62.6	53.4	759
18.0	64.4	54.7	778
19.0	66.2	56.0	797
20.0	68.0	57.3	816
21.0	69.8	58.6	836
22.0	71.6	60.0	856
23.0	73.4	61.4	876
24.0	75.2	62.9	897
25.0	77.0	64.3	918
26.0	78.8	65.8	940
27.0	80.6	67.4	962
28.0	82.4	68.9	985
29.0	84.2	70.5	1008
30.0	86.0	72.1	1031
30.9	87.6	73.6	1053

Table 8.1. Pressure-temperature chart for R744 – CO2

8.1.4. ADDITIONAL TEMPERATURE AND PRESSURE CONVERSIONS

See Table 8-1 for temperatures and pressures below the CO2 critical point. Table 8-2 lists the unit conversions for pressures and temperatures above the critical point are shown below.

Temperature		Temperature	
(°C)	(°F)	(°C)	(°F)
31.0	87.8	65.0	149.0
32.0	89.6	66.0	150.8
33.0	91.4	67.0	152.6
34.0	93.2	68.0	154.4
35.0	95.0	69.0	156.2
36.0	96.8	70.0	158.0
37.0	98.6	71.0	159.8
38.0	100.4	72.0	161.6
39.0	102.2	73.0	163.4
40.0	104.0	74.0	165.2
41.0	105.8	75.0	167.0
42.0	107.6	76.0	168.8
43.0	109.4	77.0	170.6
44.0	111.2	78.0	172.4
45.0	113.0	79.0	174.2
46.0	114.8	80.0	176.0
47.0	116.6	81.0	177.8
48.0	118.4	82.0	179.6
49.0	120.2	83.0	181.4
50.0	122.0	84.0	183.2
51.0	123.8	85.0	185.0
52.0	125.6	86.0	186.8
53.0	127.4	87.0	188.6
54.0	129.2	88.0	190.4
55.0	131.0	89.0	192.2
56.0	132.8	90.0	194.0
57.0	134.6	91.0	195.8
58.0	136.4	92.0	197.6
59.0	138.2	93.0	199.4
60.0	140.0	94.0	201.2
61.0	141.8	95.0	203.0
62.0	143.6	96.0	204.8
63.0	145.4	97.0	206.6
64.0	147.2	98.0	208.4

Pressure		Pressure	
(Bar-abs)	(psig)	(Bar-abs)	(psig)
74.1	1075	109.3	1585
75.2	1090	110.3	1600
76.2	1105	111.4	1615
77.2	1120	112.4	1630
78.3	1135	113.4	1645
79.3	1150	114.5	1660
80.3	1165	115.5	1675
81.4	1180	116.5	1690
82.4	1195	117.6	1705
83.4	1210	118.6	1720
84.5	1225	119.6	1735
85.5	1240	120.7	1750
86.5	1255	121.7	1765
87.6	1270	122.7	1780
88.6	1285	123.8	1795
89.6	1300	124.8	1810
90.7	1315	125.8	1825
91.7	1330	126.9	1840
92.7	1345	127.9	1855
93.8	1360	128.9	1870
94.8	1375	130.0	1885
95.8	1390	131.0	1900
96.9	1405	132.0	1915
97.9	1420	133.1	1930
98.9	1435	134.1	1945
100.0	1450	135.1	1960
101.0	1465	136.2	1975
102.0	1480	137.2	1990
103.1	1495	138.2	2005
104.1	1510	139.3	2020
105.1	1525	140.3	2035
106.2	1540	141.3	2050
107.2	1555	142.4	2065
108.2	1570	143.4	2080

Table 8.2. Temperature and Pressure Conversions

8.2. DEFINITIONS AND ACRONYMS

The definitions and acronyms listed below are used within this manual.

Term or Acronym	Definition
ACU	Auxiliary Condensing Unit
Bar	Unit of pressure measurement equal to 100 kPa, or 14.5 psi (Bar is Bar-gauge)
Booster System	A booster refrigeration system is type of refrigeration system where two stage compression occurs with the first stage compression discharge connected to the second stage suction in order to boost the second stage suction pressure. The first stage compression group provides cooling at a lower temperature than the second stage compression group
BPHE	Brazed Plate Heat Exchanger
Critical Point	Critical point is the end point of a phase equilibrium curve, where distinct liquid and gas phases do not exist. For CO2, the critical temperature and pressure are 87.77°F (30.98°C) and 1055 psig (73.77 bar).
Design Pressure	The maximum pressure for which a system or specific part of a refrigerating system is designed. This corresponds to the advertised maximum working pressure. For parts, this is also called: Maximum allowable working pressure Rated pressure Pressure rating
EEV	Electronic Expansion Valve
EMS	Energy Monitoring System
Enthalpy	The measure of energy content in a fluid. Measured in British thermal units per pound (Btu/lb)
EPA	Environmental Protection Agency
Expansion Device	A component that reduces the pressure and temperature adiabatically in a refrigeration system. There are several types but a thermal expansion valve is most common for air conditioning applications. The device is located in the liquid line as close to the evaporator as possible.
FGBV	Flash Gas Bypass Valve
GreenChill	EPA Program that recognizes food retailers that have implemented technology that reduces refrigerant emissions, and decreases their impact on the ozone layer and climate change.
GWP	Global Warming Potential. For exemple: (CO2/R744=1, R22=1810, R410A=2088)
Heat Recovery	Heat recovery units use the waste heat (compressor superheat) generated by the compressors in order to heat a closed loop water circulation which in turn is used to heat air, tap water, or other heating applications.
High Side	The section of the system containing all components between the MT compressor discharge and the inlet of the HPEV. All components and piping in this side of the system and piping have a design pressure of at least 120 bar (1740 psig). Typical working pressures on this side are expected between 45 and 100 bar (652 to 1450 psig) depending on ambient conditions.
Hot Gas Dump	A method of preventing liquid slugging in the MT compressors by injection of hot gas from the MT compressor discharge back to the suction controlled by a solenoid valve.
HPEV	High Pressure Expansion Valve. Also known as HPV – high pressure valve, or HPCV – high pressure control valve.
IDLH	Immediate Danger to Life and Health
Intermediate Pressure Stage	The section of the system containing all components between the HPEV outlet and the inlet of the EEV's at the cases. All components and piping in this side of the system have a design pressure of at least 45 bar (652 psig). N|vru Zduuhq Hswd XV offers an option of up to 90 bar intermediate pressure rating
Liquid Hammer	In compressors, if a considerable amount of liquid enters the compressor house, a very large pressure can be built up when the piston reaches its top position. This phenomenon is called liquid hammer, and may cause severe damage to the valves or crankshaft.
Liquid Injection	A method to control the superheat in the MT compressor suction when necessary by injecting liquid refrigerant into that stream. This will be triggered and controlled when the MT suction superheat exceeds a pre-determined set point.
Low Side	The section of the system between the outlet of the LT EEVs and suction of the LT compressors. All components and piping in this section have a design pressure of at least 30 bar (435 psig). Normal operating pressures are expected around 13 to 15 bar (188 to 218 psig).
LT (Low Temperature)	The low temperature side of a CO2 trans-critical refrigeration system is the portion that deals with the refrigerant at very low temperature and pressure, 22°F and 218 psig (30°C and 15 bar). This is generally the LT evaporator suction lines. The compressor that operates at the LT side is called LT compressor.
Micron	Microns are a measure of vacuum and equals I milliTorr or 1/1,000 of a Torr. 1 micron = 0.1333 Pascals (Pa).
MT (Medium Temperature)	The medium temperature side of a CO2 trans-critical refrigeration system is the portion that deals with the refrigerant at medium temperature and pressure (-6°C and 30 bar). This is generally the MT evaporator suction lines. The compressor that operates at the MT side is called MT compressor.
ODP	Ozone Depletion Potential. For exemple: (CO2/R744=0, R134a=0, R22=0.055, R410A=0)
Oil Management System	Both MT & LT compressors require lubrication to run in order to avoid wear & tear and overheating. The equipment and protocol that deals with circulation of oil in the compressors is known as the oil management system. The equipment for oil management systems are oil separator, oil reservoir, oil level switch, oil regulator, respective solenoid valves, crankcase heater, etc.
Parallel Compression	Parallel compression is an improved cycle configuration of CO2 Transcritical Booster refrigeration systems for warm climates. In this configuration, instead of routing the flash gas to the MT compressors suction, it connects the flash gas bypass line directly to a parallel group of compressors without dropping the pressure through the FGBV.
PRV	Pressure Relief Valve
Refrigerant	Working fluid of refrigeration system
Riser	A refrigerant pipe that runs vertically.
SOO	Sequence of Operation provides a general summary of the control functions and settings.
Subcooling	Subcooling is the process by which saturated liquid is cooled below the saturation temperature. This can be achieved by heat transfer from cold suction gas or by a dedicated evaporator.
Subcritical State	Subcritical state of fluid is any substance at a temperature or pressure below its critical point, where distinct liquid and gas phases exist. The saturation point of the fluid exists at a unique temperature and pressure.
Supercritical State	Supercritical state of a fluid is any substance at a temperature and pressure above its critical point, where distinct liquid and gas phases do not exist. Also called Supercritical Fluid.
Superheat, SH	Temperature of vapor above its saturation temperature at that pressure.
TLV	Threshold Limit Value (related to exposure to refrigerants)
Transcritical Cycle	A refrigeration cycle in which the heat rejection (condenser/gas cooler) occurs at a pressure above the critical point of the refrigerant. For CO2, the critical pressure is 1055 psig (73.77 bar).
TWA	Time Weighted Average (related to exposure to refrigerants)
Upper Cascade	The refrigerant circuit in a cascade system that removes heat from a refrigerated load and transfers the heat to the upper-cascade
VFD	Variable Frequency Drive
Working Pressure	The pressure applied to a part or system while operating. (See Design Pressure)

Table 8.3. Definitions and Acronyms

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