Installation, Operation, and Service Manual

Protocol CO_2

Medium and Low Temperature System

P/N 3226080 **Rev** A
April 2025

Certifications

WARNINGS:

If the information in these instructions are not followed exactly, use may result in property damage, personal injury, or death. Installation and service must be performed by a qualified installer or service agency.

READ THE ENTIRE MANUAL BEFORE INSTALLING OR USING THIS EQUIPMENT.

The unit uses R-744 (CO_2) as the refrigerant. If a leak is present or even suspected, evacuate the affected area and do not allow untrained personnel to attempt to find the cause.

FAILURE TO ABIDE BY THIS WARNING COULD RESULT IN AN EXPLOSION, DEATH, INJURY, AND PROPERTY DAMAGE.

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Protocol CO_2

User Safety and Product Information

Legal Disclaimer

Review all safety warnings on the case and in this manual before attempting start-up. Hussmann shall not be liable for any repair of replacement made without the written consent of Hussmann, or when the product is installed or operated in a manner contrary to the printed instructions covering installation and service which accompanied such product. Please note that failure to follow the instructions in this document may void your factory warranty.

ANSI Z535.5 Definitions

The definitions below are used to clarify the magnitude and urgency of harm and damage, considering problems arising from misuse. Relative to their potential danger, the definitions are divided into five parts according to ANSI Z535 Series.

DANGER

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to personal injury.

SAFETY INSTRUCTIONS

SAFETY INSTRUCTIONS (or equivalent) signs indicate specific safety-related instructions or procedures.

Proposition 65

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

General Safety Instructions

SAFETY INSTRUCTIONS

This manual was written in accordance with originally prescribed equipment that is subject to change. Hussmann reserves the right to change or revise specifications and product design in connection with any feature of our products.

Only qualified personnel should install and service this equipment. Personal Protection Equipment (PPE) is required. Wear safety glasses, gloves, protective boots or shoes, long pants, and a long-sleeve shirt when working with this equipment and while handling glass.

The safety of our customers and employees is paramount. The precautions and procedures described in this manual are intended as general methods for safe use of this equipment. Please be sure to comply with the precautions described in this manual to protect you and others from possible harm. Always follow OSHA standards for safety.

Observe the refrigerant type the unit is designed to work with and any and all precautions on tags, stickers, labels and literature provided and referenced for this equipment. Use only Hussmann approved parts approved through the Hussmann Performance Parts Website. Verify that all repair parts are identical models to the ones they are replacing. Do not substitute parts such as motors, switches, relays, heaters, compressors, power supplies, or solenoids. Read all safety information regarding the safe handling of refrigerant and refrigerant oil, including the Material Safety Data Sheet. MSDS sheets can be obtained from your refrigerant supplier. Service is to be performed by factory-authorized service personnel, so as to minimize the risk of possible injury due to incorrect parts or improper service. Contact your Hussmann representative to arrange servicing.

Contractors shall strictly adhere to specifications provided by the Engineer of Record (EOR), as well as US EPA regulations, OSHA regulations, and all other federal, state, and local codes. There are numerous hazards, not limited to, but including burns due to high temperatures, high pressures, toxic substances, electrical arcs and shocks, very heavy equipment with specific lift points and structural constraints, public safety, noise, and possible environmental damage.

Serial Plate Location

Serial plate is located on the control panel. Serial plate contains all pertinent information such as model, serial number, amperage rating, refrigerant type, and charge.

UL Listing

These merchandisers are manufactured to meet ANSI / UL 60335-2-89 and CSA C22.2 standard requirements for safety. Proper installation is required to maintain this listing. This appliance is to be installed in accordance with the Safety Standard for Refrigeration Systems, ANSI/ASHRAE 15.

Federal / State Regulation

These merchandisers, at the time they are manufactured, meet all federal and state/provincial regulations. Proper installation is required to ensure these standards are maintained. Near the serial plate, each case carries a label identifying the environment (temperature and relative humidity) in which the case was designed to be used.

⚠ WARNING

READ THE ENTIRE MANUAL AND ALL WARNINGS BEFORE INSTALLING OR USING THIS EQUIPMENT.

- WARNING—Read entire manual before attempting to service this product. All safety precautions must be followed.
- Installation and service must be performed by a qualified installer or service agency only as recommended by the manufacturer. Do not use any means to clean or service other than those recommended by the manufacturer.
- Contractors shall strictly adhere to specifications provided by the Engineer of Record (EOR), as well as US Environmental Protection Agency regulations, OSHA regulations, and all other federal, state and local codes. This work should only be done by qualified, licensed contractors.
- Installation and use of this unit includes numerous hazards, not limited to, but including: burns due to high temperatures, high pressures, toxic substances, electrical arcs and shocks, very heavy equipment with specific lift points and structural constraints, food and product damage or contamination, public safety, noise, and possible environmental damage.
- Never leave operating compressors unattended during the manual soft-start process. Always power rocker switches off when unattended.
- Do not store items or flammable materials atop the unit. Do not walk or climb on unit.
- This appliance is not intended for use by persons (including children) with reduced physical, sensory or mental capabilities, or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety.
- Children should be supervised to ensure that they do not play with the appliance.
- WARNING: The refrigeration system is under high pressure. Do not tamper with it. Contact qualified service personal before disposal.
- WARNING: Do not damage the refrigerating circuit.
- WARNING—Handle and dispose of refrigerant properly in accordance with federal or local regulations.
- If the system is de-energized, venting of the R-744 through the pressure regulating relief valves on the refrigeration system can occur. In such cases, the system might need to be recharged with R-744, but in any case, the pressure regulating relief valve(s) shall not be defeated or capped. The relief setting shall not be altered.
- A pressure relief device shall be installed in the high-pressure side of the refrigeration system between the motor-compressor and the gas cooler. There shall be no shut-off devices or other components except piping between the motor-compressor and the pressure relief device that could introduce a pressure drop.
- A sufficient number of pressure relief and pressure-regulating relief valves might need to be provided based on the system capacity and located such that no stop valve is provided between the relief valves and the parts or sections of the system being protected.
- The pressure relief device shall be mounted so that any refrigerant released from the system during its operation cannot cause harm to the user of the appliance. The aperture shall be located so that it is unlikely to be obstructed in normal use.
- The installed pressure relief device shall have no provisions for setting by the end user.

⚠WARNING

- The pressure setting of the installed pressure relief device shall be no higher than the design pressure of the high-pressure side.
- Piping in refrigeration systems shall be so designed and installed to minimize the likelihood of hydraulic shock damaging the system. Solenoid valves shall be correctly positioned in the piping to avoid hydraulic shock.
- Solenoid valves shall not block in liquid refrigerant unless adequate relief is provided to the refrigerant system low pressure side.
- Factory installed refrigerant sensors or detectors shall not be disconnected.
- If a leak is present or even suspected, do not allow untrained personnel to attempt to find the cause.
- A hand-held leak detector (“sniffer”) will be used before any repair and/or maintenance.
- Protection devices, piping, and fittings shall be protected as far as possible against adverse environmental effects, for example, the danger of water collecting and freezing in relief pipes or the accumulation of dirt and debris.
- Piping material, pipe routing, and installation shall include protection from physical damage in operation and service, and be in compliance with national and local codes and standards, such as ANSI/ASHRAE 15, IAPMO Uniform Mechanical Code, ICC International Mechanical Code, or CSA B52. All field joints shall be accessible for inspection prior to being covered or enclosed.
- Always use a pressure regulator when operating nitrogen tanks.
- The installation of pipe-work shall be kept to a minimum.
- Provision shall be made for expansion and contraction of long runs of piping.
- Flexible pipe elements shall be protected against mechanical damage, excessive stress by torsion, or other forces, and that they should be checked for mechanical damage annually.
- After completion of field piping for split systems, the field pipework shall be pressure tested with an inert gas and then vacuum tested prior to refrigerant charging, according to the following requirements:

1. The minimum test pressure for the low side of the system shall be the low side design pressure and the minimum test pressure for the high side of the system shall be the high side design pressure, unless the high side of the system cannot be isolated from the low side of the system in which case the entire system shall be pressure tested to the low side design pressure.
2. The test pressure after removal of pressure source shall be maintained for at least 1 h with no decrease of pressure indicated by the test gauge, with test gauge resolution not exceeding 5 % of the test pressure.
3. During the evacuation test, after achieving a vacuum level specified in the manual or less, the refrigeration system shall be isolated from the vacuum pump and the pressure shall not rise above 1,500 microns within 10 min. The vacuum pressure level shall be specified in the manual, and shall be the lessor of 500 microns or the value required for compliance with national and local codes and standards, which may vary between residential, commercial, and industrial buildings.

- Mechanical connections made in accordance shall be accessible for maintenance purposes.

⚠WARNING

- LOCK OUT / TAG OUT — To avoid serious injury or death from electrical shock, always disconnect the electrical power at the main disconnect when servicing or replacing any electrical component. This includes, but is not limited to, such items as doors, lights, fans, heaters, and thermostats.
- To avoid serious injury or death from electrical shock, always disconnect the electrical power at the main disconnect when servicing or replacing any electrical component.
- Means for disconnection must be incorporated in the fixed wiring in accordance with the wiring rules.
- Unit must be grounded. All wiring must be in compliance with NEC and local codes.
- Failure to follow code could result in death or serious injury. All field wiring MUST be performed by qualified personnel. Improperly installed and grounded field wiring poses FIRE and ELECTROCUTION hazards. To avoid these hazards, you MUST follow requirements for field wiring installation and grounding as described in NEC and your local/state electrical codes
- Check that cabling will not be subject to wear, corrosion, excessive pressure, vibration, sharp edges, or any other adverse environmental effects. The check shall also take into account the effects of aging or continual vibration from sources such as compressors or fans..
- Particular attention shall be paid to ensure that by working on electrical components, the casing is not altered in such a way that the level of protection is affected. This shall include damage to cables, excessive number of connections, terminals not made to original specification, damage to seals, incorrect fitting of glands, etc.
- Component parts shall be replaced with like components, and servicing shall be done by factory authorized service personnel only, so as to minimize the risk of possible damage due to incorrect parts or improper service.
- If it is absolutely necessary to have an electrical supply to equipment during servicing, then a permanently operating form of leak detection shall be located at the most critical point to warn of a potentially hazardous situation.
- Do not apply any permanent inductive or capacitance loads to the circuit without ensuring that this will not exceed the permissible voltage and current permitted for the equipment in use.
- Be careful when moving or lifting Protocol. Serious bodily injury or death could occur from falling equipment.
- Precautions shall be taken to avoid excessive vibration or pulsation.
- WARNING: Keep clear of obstruction, all ventilation openings in the appliance enclosure.
- Any insulation shall be suitable for use with the material being insulated.
- Ensure that the apparatus is mounted securely. Do not use adhesives to fix the unit in place, since they are not considered to be a reliable fixing means.
- When servicing, ensure that seals or sealing materials have not degraded. Replacement parts shall be in accordance with the manufacturer’s specifications.

FAILURE TO ABIDE BY THESE WARNINGS COULD RESULT IN AN EXPLOSION, DEATH, INJURY, AND PROPERTY DAMAGE. READ ALL WARNINGS PRIOR TO INSTALLING, PERFORMING MAINTENANCE, OR SERVICING THE EQUIPMENT IN ANY WAY.

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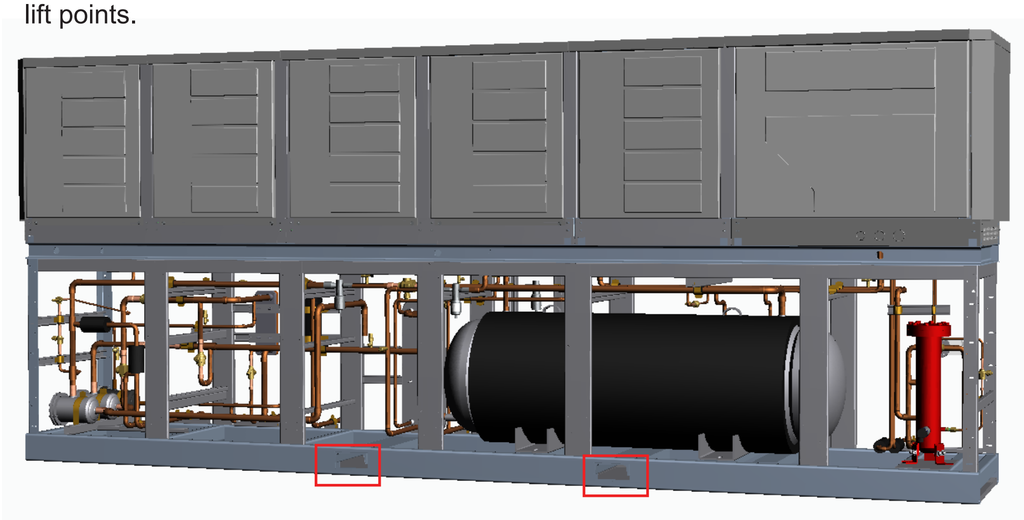
User Safety and Product Information

Hussmann Product Control

Serial number and shipping date of all equipment are recorded in Hussmann's files for warranty and replacement part purposes. All correspondence pertaining to warranty or parts ordering must include the serial number of each piece of equipment involved. This is to ensure the customer is provided with the correct parts.

Handling

Each unit has a lower base frame with forklift provisions. Do not attempt to lift or move the unit using other lift points.



Shipping Damage

All equipment should be thoroughly examined for shipping damage before and during unloading. This equipment has been carefully inspected at our factory. Any claim for loss or damage must be made to the carrier. The carrier will provide any necessary inspection reports and/or claim forms.

Apparent Loss or Damage

If there is an obvious loss or damage, it must be noted on the freight bill or express receipt and signed by the carrier's agent; otherwise, carrier may refuse claim.

Concealed Loss or Damage

When loss or damage is not apparent until after equipment is uncrated, retain all packing materials and submit a written response to the carrier for inspection within 15 days.

Protocol Components

Each Protocol includes 3-7 scroll compressors and factory piping with:

- Suction, discharge, liquid header
- Defrost header (if applicable)
- Oil separator, oil reservoir and return system
- Flash tank
- Suction filters on each suction group
- Liquid filter drier and sight glass
- Liquid level switch
- High and low pressure controls
- Oil pressure safety control
- Primary overload protection
- High pressure, economizer, and flash gas valves

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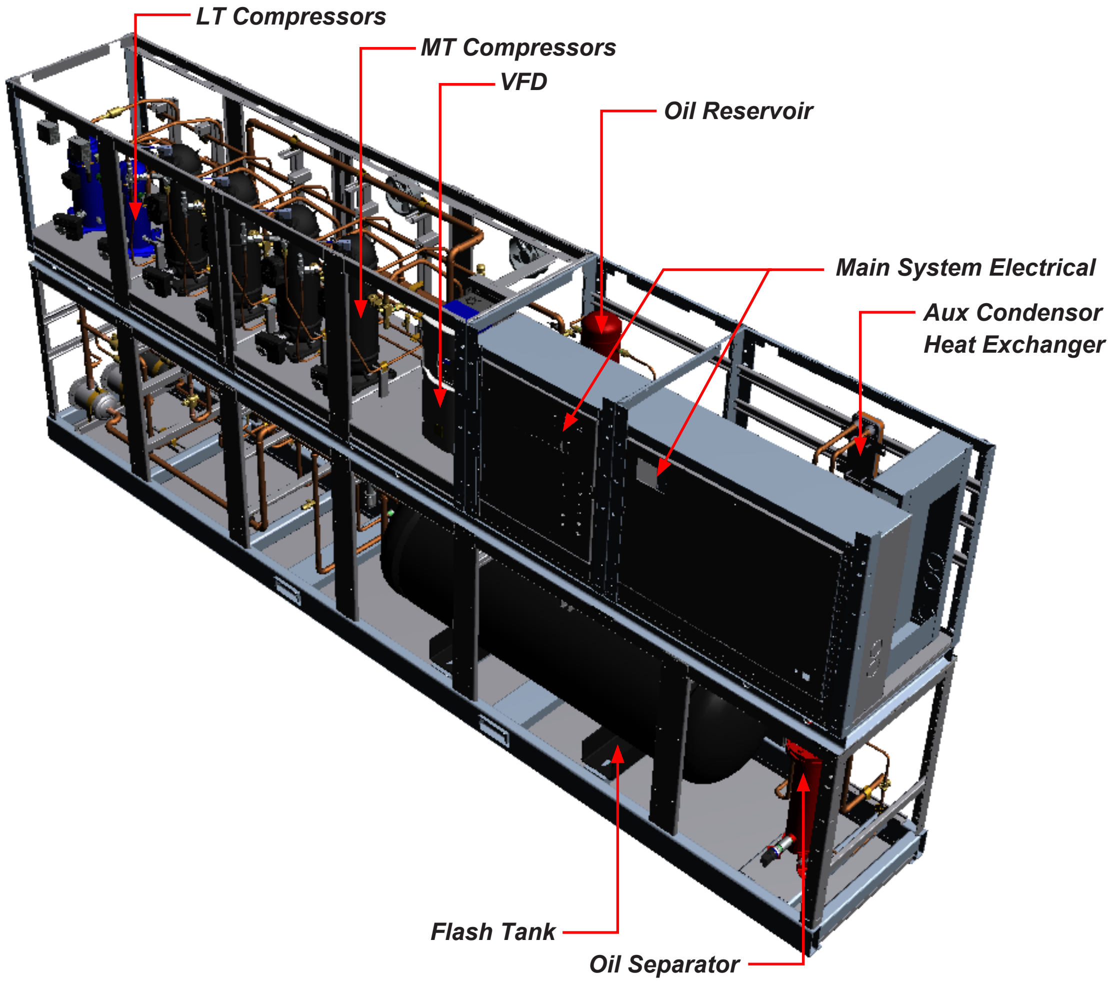
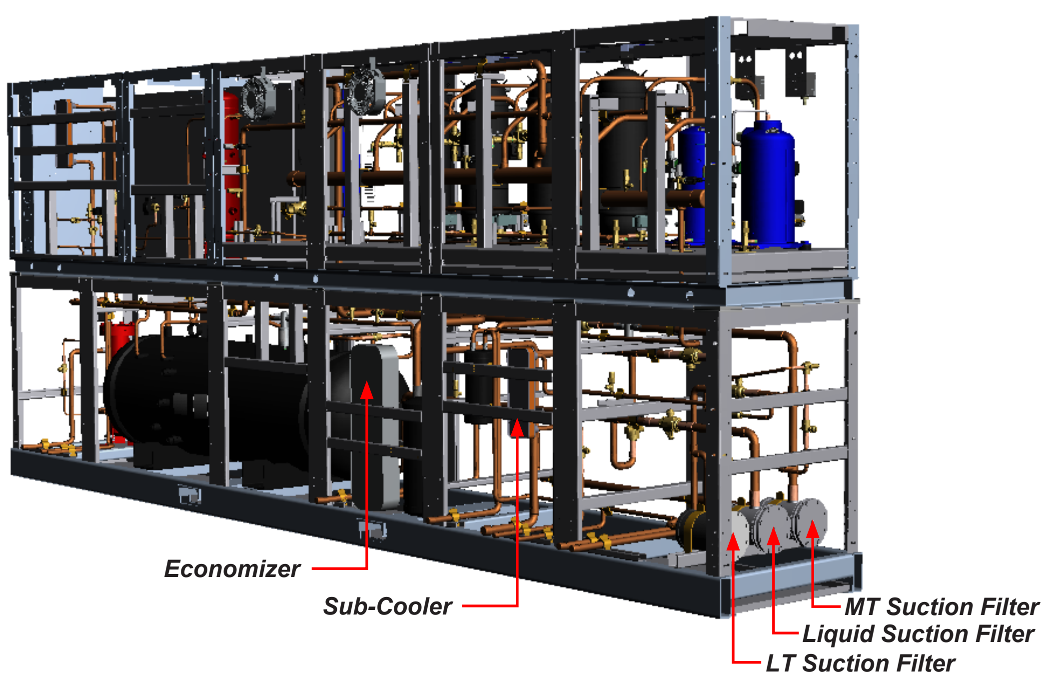
User Safety and Product Information

Protocol Component Views





Introduction to Transcritical R-744 (CO_2)

This manual provides general information that covers the installation, startup, maintenance, and service of centralized transcritical systems using carbon dioxide (R-744 / CO_2). For detailed information regarding a specific component or application contact your Hussmann representative.

Additional specifications for job-specific site installation may include:

- Legend of equipment load and electrical requirements
- Site-specific sequence of operations
- Specifications of components
- Piping diagrams
- Site-specific dimension and lifting requirements
- Equipment overview and list of options

CO_2 Quality

- CO_2 that is purchased for use in refrigeration systems should be of a purity level high enough to prevent accumulation of non-condensible gases and moisture. A build-up of these gases can block small orifices (such as expansion valves) or lead to high discharge pressure, reducing operation or causing the system to become inoperable.
- CO_2 is commercially available at several different purity levels. The common names and percent purity are listed below. Hussmann recommends using “Refrigeration Grade” (99.99% purity) CO_2.
- Mixing of higher purity grades of CO_2 is acceptable. Lower grades of CO_2 contain higher levels of contaminants and water and will decrease system performance. Higher levels of moisture may react with the CO_2 and form carbonic acid that can degrade component integrity. Hussmann recommends keeping enough refrigeration grade CO_2 on-site to charge the system.
- Medical grade CO_2 should not be used, due to the outlet pressure regulators typically present on tanks.
- Bone-Dry grade is the minimum acceptable purity to ensure proper operation of the equipment and is pure enough to technically prevent accumulation of non-condensible gases in the system.
- R-744 (CO_2) purity:

R-744 (CO_2) Grade	Purity
Industrial and Medical Grade	99.5%
Bone Dry (minimum acceptable)	99.8%
Anaerobic Grade	99.9%
Refrigeration Grade (R-744, recommended)	99.99%
Coleman/Instrument Grade	99.99%
Research Grade	99.999%
Ultra-Pure Grade	99.9999%

Before Working with R-744 (CO_2) Refrigerant

Safety Checks

- R-744 (CO_2) systems have similar safety concerns with all conventional refrigerants, in that it displaces oxygen, is heavier than air and will concentrate closer to the floor if there is a system leak. R-744 should be monitored for leaks similar to other refrigerants.
- Confirm operation of leak detectors (e.g., by exhaling near the sensor), audible / visible alarms, and machine room ventilation before operation.
- Ventilate adjacent enclosed areas to prevent the formation of dangerous concentrations of carbon dioxide.
- Personnel including rescue workers should not enter areas in which the carbon dioxide content exceeds 3% (30,000ppm) by measurement unless wearing an SCBA or supplied-air respirator.
- Avoid contact of the skin or eyes with solid carbon dioxide (dry ice) or objects cooled by solid carbon dioxide.
- Additional information on the safe use and handling of carbon dioxide can be found in Standards from the Compressed Gas Association Standard (www.cganet.com).
- The following checks shall be applied to installations:

  a. The actual REFRIGERANT CHARGE is in accordance with the room size within which the refrigerant containing parts are installed.
  b. The ventilation machinery and outlets are operating adequately and are not obstructed.
  c. If an indirect refrigerating circuit is being used, the secondary circuit shall be checked for the presence of refrigerant.
  d. Marking to the equipment continues to be visible and legible. Markings and signs that are illegible shall be corrected.
  e. Refrigerating pipe or components are installed in a position where they are unlikely to be exposed to any substance which may corrode refrigerant containing components, unless the components are constructed of materials which are inherently resistant to being corroded or are suitably protected against being so corroded.

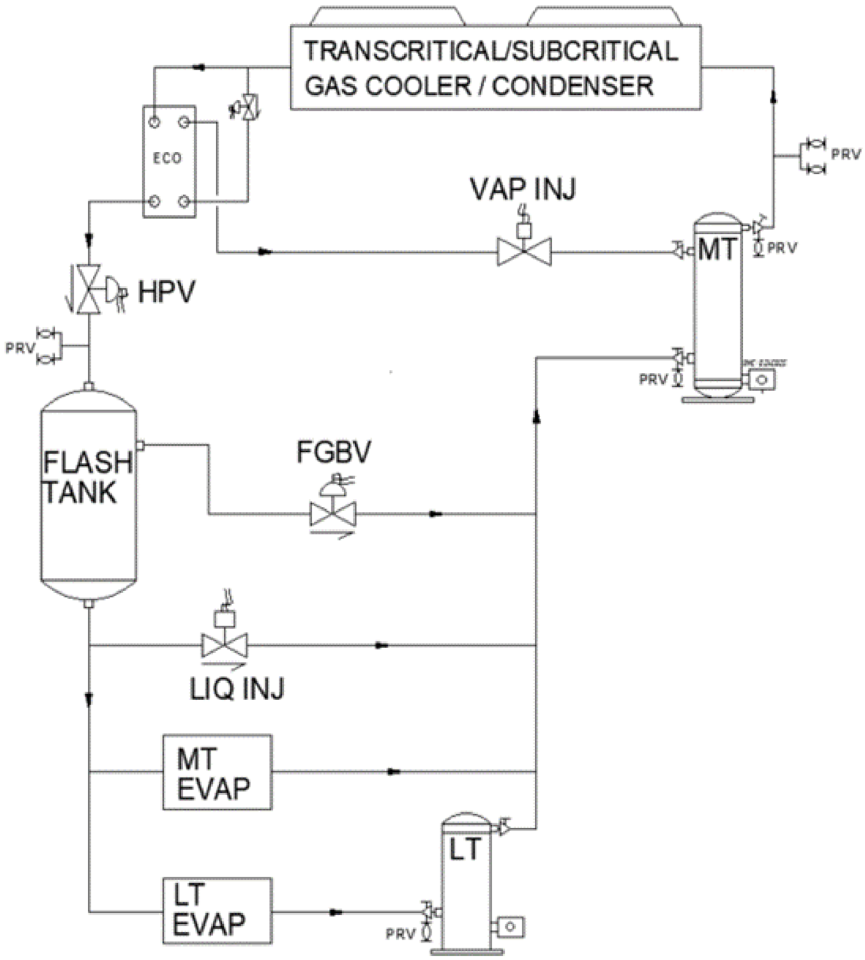
Asphyxiation

- R-744 is colorless, odorless, heavier than air, and is an asphyxiant gas. If sensor reading is maxed out or non-responsive assume an unsafe level of CO_2 and ventilate the room prior to entering.
- Practical limit of R-744 is 0.006 lb/ft3 (56,000 ppm).
- A leak of R-744 could result in a concentration exceeding the practical limit in an enclosed, occupied space such as a cold room. Precautions must be taken to prevent asphyxiation. These include the use of permanent leak detection, which activates an alarm in the event of a leak.
- The practical limit is defined in ASHRAE 34 but may vary depending on regional regulations. The table below summarizes the effect of R-744 at various concentrations in the air.

PPM of R-744 (CO_2)	Effects
442	concentration in atmosphere
5,000	long-term exposure limit (8 hours)
15,000	short-term exposure limit (10 minutes)
30,000	discomfort, breathing difficulties, headache, dizziness, etc.
100,000	loss of consciousness, followed by death
300,000	quick and immediate death

Transcritical R-744 (CO_2) System Diagram

R-744 has found use in a wide variety of system layouts. Below is an example diagram of a transcritical R-744 (CO_2) system.



System Overview

This refrigeration systems uses naturally occurring, environmentally friendly, and energy efficient R-744 (CO_2) that is compliant with federal environmental regulations.

This equipment is designed with a medium temperature discharge (high side) that has 1,740 psig (120 bar) max. pressure. The “high side” suction handles all medium temperature (MT) loads for the store as well as the low temperature discharge which has a max. pressure of 600 psig and flash tank flash (liquid line) with 652 psig (45 bar) max pressure. The maximum low temperature suction (low side) for low temperature (LT) loads has 500 psig (34.5 bar) max. pressure. The medium temperature suction (intermediate side) liquid CO_2 (600 psig [41.4 bar] or 652 psig [45 bar] max. depending on system configuration) is sent to store medium and low temperature evaporators.

The MT part of the system needs to be running before running the LT compressors. The LT discharge helps manage a reasonable superheat at the MT compressors. A liquid to LT suction plate heat exchanger is utilized to help provide a reasonable superheat at the LT compressors while subcooling liquid.

Legend and Labeling

Each Protocol is shipped with a detailed legend that identifies the specialized components used such as compressors, valves, oil separators, etc., and details BTU/hr loads, control valves, circuit information, and suction temperatures. The type of refrigerant and lubricant to be used are prominently displayed on the front of the Protocol. All Protocol units include complete wiring diagrams (control, primary power, board and point layout) packed into one of the panels. All wiring is color coded.

System Inspection

Upon delivery of the unit(s), verify that the correct unit and equipment is received by comparing the information on the unit serial plate with the ordering and submittal documents. All equipment should be thoroughly examined for shipping damage before and during unloading. This equipment has been carefully inspected at our factory and any claim for loss or damage must be made to the carrier. The carrier will provide any necessary inspection reports and/or claim forms.

In addition to the legend, each Protocol has specific set points:

- Discharge high pressure switch cut-out 1,653 psig (114 bar) / cut-in 1,537 psig (106 bar)
- MT suction pressure switch (adjustable) 310 psig (21.4 bar)
- LT suction pressure switch (adjustable) 145 psig (10 bar)
- MT suction low pressure 345 psig (24 bar)
- LT suction low pressure 160 psig (11 bar)
- Flask tank pressure 565 psig (39 bar)

System Nomenclature

TCH204MBIA

- Transcritical CO_2
- Unit Type (H=Horizontal Protocol)
- Number of Suction Groups [A]
- Two-Digit Number Representing Total Number of Compressors (01–09)
- Power Voltage (M=460/3/60)
- Application (B=Booster)
- Unit Location (I=Indoor)
- Variation (A=Standard)

[A] Contact Hussmann Design Engineering for additional information

Glossary

Terms

Compressor: This is a device that compresses the refrigerant from a low-pressure low temperature gas to a high pressure high temperature gas and provides mass flow of refrigerant throughout the system.

Electronic Expansion Valve: This is a device built to control the amount of superheat at the evaporator and the air temperature.

Flash Tank: The flash tank is designed to separate the vapor and liquid phases of CO_2. Gravity causes the liquid to settle to the bottom of the Flash Tank where it is withdrawn to enter the inlet of the Liquid Line. This is also referred to as the Liquid Vapor Separator.

Liquid Filter Drier: This is a device designed to filter impurities.

Liquid/Suction Heat Exchanger: This is a device built for efficient heat transfer between the liquid line and suction line of the primary refrigerant. This device also sub-cools the liquid refrigerant and aids in the complete evaporation of the suction gas.

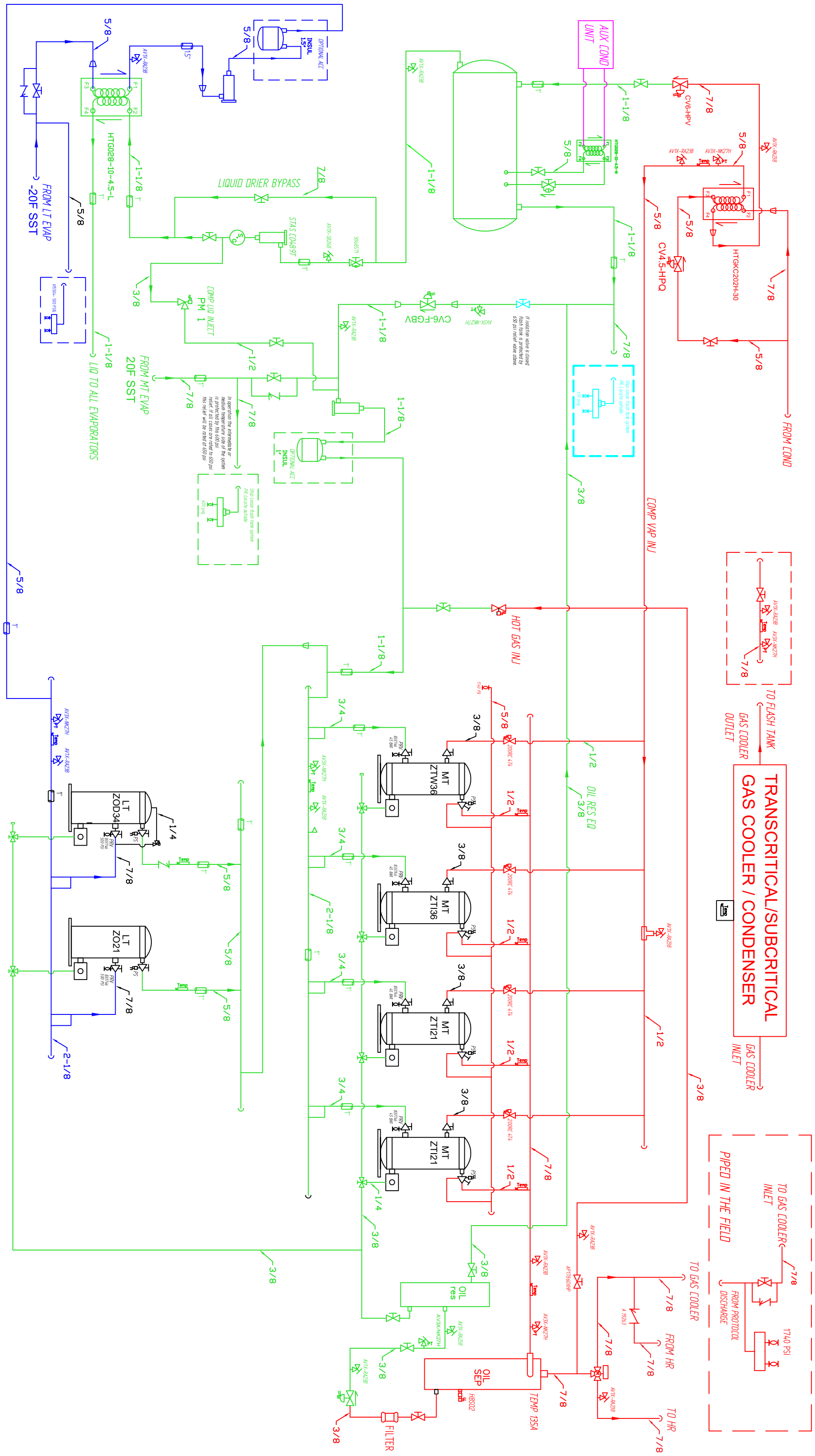
Pressure Relief Valve: The main pressure relief valves (652 psig [45 bar]) and are designed to vent CO_2 at a low rate through a small orifice. Piping should not be added to the outlet of this device to prevent the possibility of dry ice from forming and reducing the ability for this valve to vent. These are ASME calibrated to vent and are also designed to re-seat after the pressure has reduced to approximately 580 psig (40 bar)—10% blow-down.
This valve should not be replaced if it vents, only if it is not able to re-seat.

Refrigerant: A fluid used to freeze or chill (as food) for preservation. A refrigerant, such as carbon dioxide (CO_2), is used to remove heat from cases and unit coolers and transfer the heat to the gas cooler.

Abbreviations

BPHE	Brazed Plate Heat Exchanger	**MOPD**	Maximum Overcurrent Protective Devices
EEV	Electronic Expansion Valve (aka EXV)	**MT**	Medium Temperature
EV	Economizer Valve	**PLM**	Phase Loss Monitor
HG	Hot Gas	**PRV**	Pressure Relief Valve
HPV	High Pressure Valve (also ICMTS, Gas Cooler Valve, GCV)	**SC**	Subcritical
LT	Low Temperature	**SST**	Saturated Suction Temperature
MCA	Minimum Circuit Ampacity	**TC**	Transcritical

System Piping Diagram



Control Panel

The control panel contains all the necessary energy management components and motor controls factory-wired to the compressors. The interconnected compressors are cycled on and off by a central controller to match refrigeration capacity with load requirements.

Factory-wired control panel has:

- Pre-wired distribution power block
- Individual component circuit breakers and contactors
- Color-coded wiring system

Items supplied separately for field installation:

- Liquid drier cores
- Vibration isolation pads
- Loose shipped items for accessories
- Suction filter cores

Electronic Oil Level Regulators

For any brand of electronic oil level regulator to work accurately, the unit and each compressor must be level. A sight glass filled with oil may indicate a damaged regulator.

Electronic Controller

The electronic controller uses a suction transducer to “read” the suction manifold pressure. From this, sequence compressors are turned on or off through a relay board to achieve the target suction pressure.

Time Delay

Automatic time delays are built into most electronic controllers. This helps avoid short cycling.

Pressure Switches

There are basically two pressure switches in the compressor control circuit. A low-pressure switch is used to close the control circuit during high suction and open the circuit during low suction pressure. A high-pressure switch is used to open the control circuit during a critical high discharge pressure state. The high-pressure switch is available in automatic reset.

For proper setting of switches, see control settings section.

Crankcase Heaters

A crankcase heater is used to alleviate liquid migration to the compressor during off cycle periods. The crankcase heater is interlocked through the compressor contactor and is to be powered when the compressor is not running.

Defrost Controls

There are many types of defrost circuits and they are controlled by the case controller.

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Refrigeration Temperature Controls

The control of the evaporator is performed via case controller. The case controller is capable of managing both the air temperature and the superheat of the coil using the electronic expansion valve. When a stepper type expansion valve is used, it's recommended to install a liquid line solenoid prior to the valve in case of power failure so the evaporator does not flood back to the Protocol.

Alarm Control

Alarm System

The Protocol basic alarm package includes alarms for:

- Oil failure (each compressor)
- Phase loss
- Low liquid level
- High suction pressure
- High discharge pressure
- Compressor failure
- High flash tank pressure
- Low flash tank pressure

Ladder diagrams emphasize the circuit continuity and logic. They aid troubleshooting and testing by identifying point-to-point connections and color coding rather than just physical location. A ladder diagram normally moves from left to right so the user can "read" the series of switches, relays, terminals, and components that make up a circuit.

Alarm Control (Electronic)

When an electronic protocol controller is utilized, all alarm functions are performed by the Protocol controller. High suction and high discharge pressures are "read" by transducers connected to the Protocol controller. The liquid level is a digital input.

Phase loss, oil failure, and the compressor failure alarms are connected to the Protocol controller through a digital input. An optional modem can be installed to allow the Protocol controller to call out any refrigeration alarms.

Alarm Systems

The following alarms are available for use with the CO_2 system:

1. Refrigerant Loss Alarm/Indicator: An alarm trips if the refrigerant level in the flash tank drops below a set level. This alarm automatically compensates for changes in liquid level occurring during heat reclaim.
2. Single Phase Protection: This shuts down the control circuit during single phasing of the power circuit; automatically resets when three phase power is restored.
3. Remote Alarm: In event of a power outage or any alarm condition, an alarm will sound at another location, such as a burglar alarm monitoring station or answering service.

Inverter Control

An inverter is used to vary the speed of a compressor which in turn varies the capacity of that compressor. With the ability to vary the capacity of a compressor, refrigeration requirements can be better matched to the load.

Electrical Overview

Unit-specific wiring diagrams/ wiring schematics are located in one of the panels on each Protocol. Protocols are wired for 460 VAC / 3-phase / 60 Hz. The control circuit is powered from main fed and control voltage is 120 VAC. Refer to the serial plate located on the control panel to determine MCA and MOPD. Refer to merchandiser datasheets for electrical supply requirements for cases.

Field Wiring

Protocol components are wired as completely as possible at the factory with all work completed in accordance with the National Electrical Code (NEC). All deviations required by governing electric codes will be the responsibility of the installer.

The lugs on the circuit breaker package in the compressor control panel are sized for copper wire only.
All wiring must be in compliance with governing electrical codes.

Based on the full load amps of the system, select the largest connectible wire size (based on no more than three wires in the wireway and 86° F (30° C) environment per NEC).

Total connected FLA largest connectible wire:
140 A (max) 00 per 248 A (max) 350 mcm
408 A (max) 2x (250 mcm) per 608 A (max) 2x (500 mcm) per

Include control circuit amps if single point connection transformer option is used; 6 A for 460 V systems (refer to NEC for temperature correction factors).

Sizing Wire And Over-Current Protection

Check the serial plate for Minimum Circuit Ampacity (MCA) and Maximum Overcurrent Protective Devices (MOPD). Follow NEC guidelines.

Merchandiser Electrical Data

Technical datasheets are available for all merchandisers. Datasheets provide merchandiser specifications such as electrical data, electrical schematics (where available), and performance data. Refer to the technical datasheets and merchandiser serial plate for electrical information on those units.

Merchandiser Field Wiring

Field wiring must be sized for component amperes stamped on the serial plate. Actual ampere draw may be less than specified. Field wiring from the refrigeration control panel to the merchandisers is required for defrost termination thermostats and for optional refrigeration thermostats. When multiple display cases are on the same defrost circuit, the defrost termination thermostats are wired in series.

WARNING: Always check the serial plate for component amperes.

Electrical Connections

All wiring must be in compliance with NEC and local codes. All electrical connections are to be made in the electrical wireway or handy box.

Electrical Diagrams

All electrical schematics reflect the standard ladder diagram. Electrical schematics are included with each Protocol. Please keep in mind all diagrams in this manual are only examples. Wiring may vary, refer to the diagram included with each Protocol. To focus on circuit logic, the diagram may separate a relay coil and its contacts. Electrical terminal connections are clearly numbered and aid in troubleshooting should a problem arise.

Cooler Door Switch Wiring

Check the store legend for door switch requirements. The switch must be mounted to the cooler door frame and must be wired to control the electronic expansion valve and the fan circuit.

Hussmann Corporation • Bridgeton, MO 63044-2483 U.S.A. • www.hussmann.com
U.S. & Canada 1-800-922-1919 • Mexico 800-890-2900

Component Wiring Guidelines

Check the store legend for components requiring electrical circuits to either the panel, which may include:

- Remote alarm
- Electronic temperature probe
- Defrost termination thermostat
- Heat reclaim contact or 24V supply

1. Disconnect all power sources, and if the equipment has a dual power source, disconnect both and follow NEC guidelines when installing wires or changing components.
2. When running control wires for a 120 V separate power circuit, the voltage rating of the wire should be at least 600 V.
3. Use caution not to damage any assembled wires during installation and when removing the knockouts. Use appropriate strain reliefs so that no nick or burr could cause insulation damage.
4. Ensure the appropriate length of wire is used, and when running the wires allow adequate spaces and creepage distances as permitted by NEC.

All thermostat wires should be sized for Protocol control circuit breaker. Refer to the controller manufacturer's literature for temperature sensor wiring. Check field wiring requirements for appropriate quantity of wires.

Other Controls

Refer to the wiring schematics included with the Protocol when other controls are used.

Compressor Control Wiring

Each control panel is wired with independent compressor control circuits so any compressor can be electrically isolated without causing the other compressors to be shut down. A typical compressor control will consist of the following:

- Electrical control
- Low pressure switch
- High pressure switch
- Oil pressure switch
- Overload contact (if used)
- Contactor coil
- Crankcase heater (optional)
- Lighted toggle switch

Terminal pins will be used between control points for easy testing and troubleshooting.

Cooler Door Switch Wiring

Check the store legend or electrical plans for door switch kits. The switch must be mounted to the cooler door frame and must be wired to control the electronic expansion valve and evaporator fans. Door switches are wired in series.

Typical System Operation Requirements

The low temperature compressors are boosted by the medium temperature compressors to the condenser gas cooler. The high compression ratio for low temperature CO_2 compressors would result in excessively high discharge temperatures, of which the industry does not provide components for (e.g., compressors, piping, etc.).

Piping the LT compressors into the MT suction significantly decreases the power consumption of the LT compressors, but increases the MT load. This design is also beneficial for managing the MT superheat, as CO_2 systems require higher superheat than typical refrigeration systems (e.g., 36°–52° F). The LT compressors help mitigate low superheat concerns from the flash gas bypass valve and low superheat from the evaporators.

Medium temperature suction groups must have at least one compressor available in order for LT compressors to run. If for any reason all MT compressors are not available (e.g., off on oil, safety line, high pressure, phase loss, etc.), the LT compressors must be locked out, otherwise opening the MT suction pressure relief could result.

Additional notes regarding above basic operation control strategy:

- The order in which compressors are staged may be handled internally by the EMS controller. It may be required to configure each compressor's power, capacity, or displacement.
- VFD or digital unloaders fill in and create overlaps between compressor steps.
- Ensure the variable speed compressor ramps up and down appropriately between stages. When the suction pressure is unstable, it is not expected that the variable compressor reaches max speed before staging up and reaches min speed before staging down.
- When modulating compressor capacity up to bring suction pressure lower toward setpoint, analog output may not always bring the compressor capacity to 100 percent before cycling other compressors.
- Stage timer delays may be shortened due to excessive suction pressure.
- Set proportional band or neutral zone band to limit compressor cycling to under 40 cycles per day.
- Settings will be configured to accommodate safe compressor use. Copeland recommends a maximum of ten starts per hour, which means a minimum of six minutes between starts (compressor safety SL1 parameter).

Control Settings

There are two potential control settings, which are required to be set up by factory prior to startup:

- Inverter settings

IMPORTANT INSTALLATION INFORMATION

Machine Room Requirements

Equipment must be located in a dedicated operating area to provide enough working space for service personnel and meet applicable electrical codes. Hussmann recommends ventilation should be a minimum of 65 CFM per compressor unit horsepower. The air inlet should be sized for a maximum of 500 FPM velocity. Ventilation fans should cycle by thermostatic control.

Proper ventilation provides needed airflow across the compressors that helps maintain the operation of the Protocol. Ductwork may be necessary. All ventilation equipment is field-supplied and installed. Check national and local codes for ventilation requirements before installation.

The equipment room floor must solidly support the compressor unit as a live load. Ground level installation seldom presents problems, but a mezzanine installation must be carefully engineered. A concrete base must be built on the mezzanine floor to keep mechanical vibrations and noise to an acceptable level.

Recommended spacing is site specific. It is the installer's responsibility to check local codes and standards.

Protocol and Gas Cooler Placement

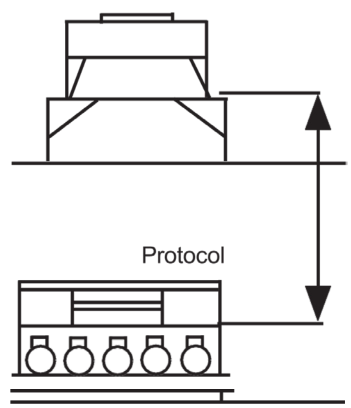
Observe the minimum distances as described below for setting the Protocol in relation to other refrigeration equipment.

Minimum Allowable Distances:

<u>Air-cooled Gas Cooler</u>

The gas cooler should preferably be located at or above the mounting surface of the Protocol. If the gas cooler is mounted well below the Protocol, consult with Hussmann for proper piping practices. If the gas cooler is located more than 15 ft above the Protocol mounting surface, install an oil trap on vertical lines every 10 to 15 ft.

Locate the gas cooler with at least three feet of clearance on all sides to provide adequate air circulation if not otherwise specified by the gas cooler manufacturer. If roof-mounted, place on column-supported beams or load-bearing walls.



Floor Drain

A floor drain must be provided for disposal of condensate that may form on the compressor unit.

Evaporator Mounted Liquid Line Solenoid

Power for a liquid line solenoid in the merchandiser can be picked up from the fan circuit (check fan motor and solenoid voltages first).

Vibration Pads

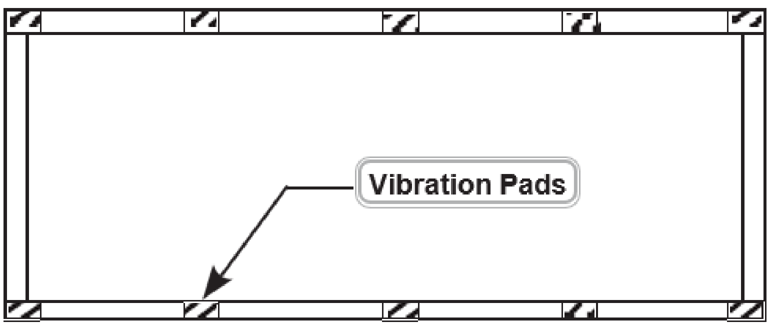
Each Protocol must be located in the machine room so that it is accessible from all sides. A minimum of 36 inches of clearance is recommended to provide easy access to components. Vibration isolation pads are supplied with each Protocol. The entire weight of the Protocol must rest on these pads. The pads should be located as shown in the image below. Cross-level the compressor unit so all compressors are level with each other.

WARNING: Be careful when moving or lifting Protocol. Serious bodily injury or death could occur from falling equipment.

Vibration Pad Installation:

1. Lift the Protocol following local, state and federal requirements for safety.
2. Place minimum 15-gauge 3 in. by 3-in. galvanized or stainless steel shims to compensate for uneven floors. (shims must be field supplied)
3. Place vibration isolation pads on top of shims, evenly distributed along the base of the unit. There are ten pads for each unit; all ten must be used.

Note: Pads should be placed over structural joist members when Protocol is placed on sub-floor.



Piping Overview

All protocol factory piping is copper-iron piping.

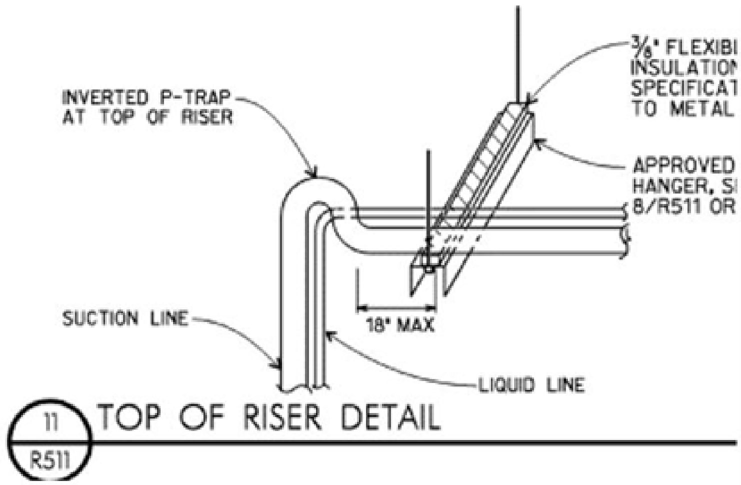
This section provides information for installing the refrigeration lines for a Protocol. The components are piped as completely as practical at the factory. Field piping requires only interconnection of the major components and the coolers, freezers, and display cases. Piping must also be supported to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

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

Vertical risers should be supported within 18 in. of the inverted trap.

Hanger should attach to top chord of the rafter/truss.

WARNING: Always use a pressure regulator when operating nitrogen tanks.



Copper Tubing and Fittings

Brazed joints should be made with standard industry practices. A minimum of 15% silver-solder is required for all copper to copper brazed joints.

Insulation requirements should follow job specifications. Standard tube bracing and supports are required, and standard suction practices are required (trapping and proper riser sizing).

Maximum Spacing Between Pipe Supports for Copper Tubing

Nominal Diameter (OD)	Maximum Span in Feet
5/8”	5
7/8”	6
1 1/8”	7
1 3/8”	8
1 5/8”	9
2 1/8”	10
2 5/8”	11
3 1/8”	12
3 5/8”	13
4 1/8”	14

Refrigeration Line Runs

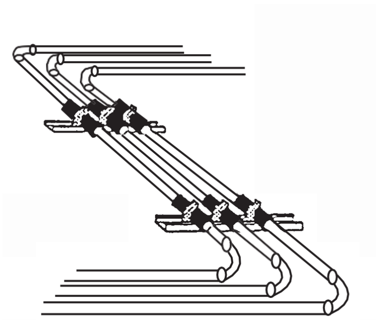
Liquid lines and suction lines must be free to expand and contract independently of each other. Do not clamp or solder them together. Supports must allow tubing to expand and contract freely. Do not exceed 100 feet without a change of direction and/or offset.

Pitch horizontal suction lines toward the compressor Protocol with a slope of 1/2" for every 10 feet. All suction risers should have a p-trap installed at the base of the riser and have an inserted trap installed at the top of the riser. All traps should be the same diameter as the horizontal run. Install a suction midpoint p-trap for every 16' of vertical rise. Install a one-piece trap for both the base and inverted trap.

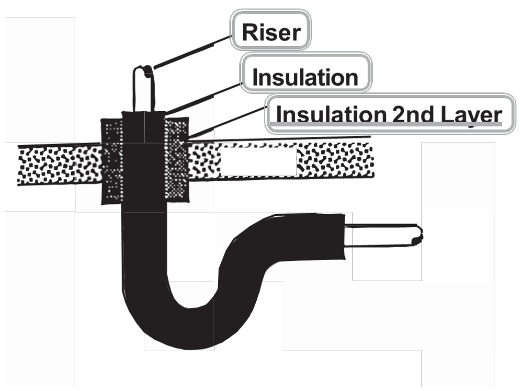
Use long radius elbows to reduce line resistance and breakage. Avoid the use of 45-degree elbows. Install service valves at several locations for ease of maintenance and reduction of service costs. These valves must be UL approved for the minimum design working pressure of the system.

Piping Through Walls and Floors

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

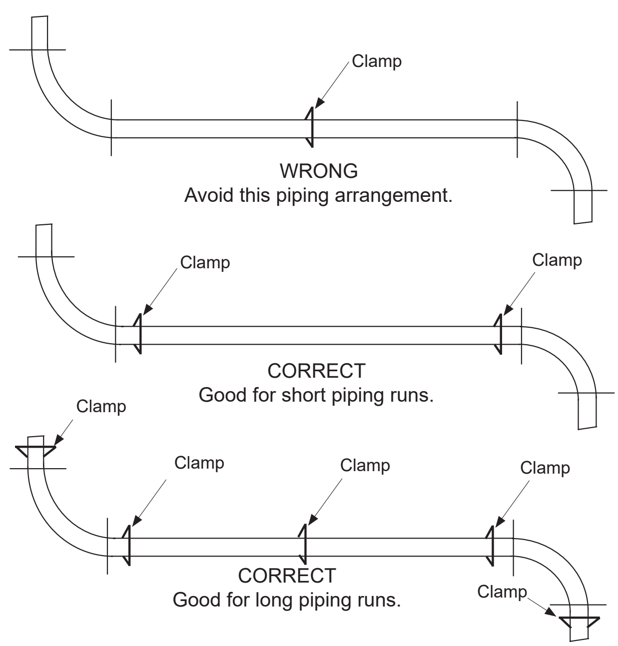


Floor Piping Run

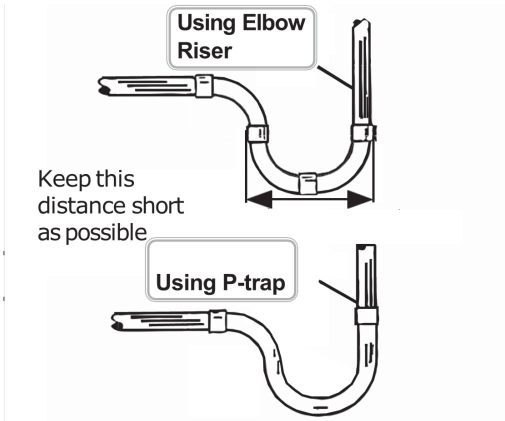


Piping From Machinery to Solid Object

When mounting lines from machinery to a solid object, allow line to be able to move appropriately to prevent metal fatigue from vibration. Do not over support piping that is in contact with the compressor. The machinery must not be tightly stressed from piping that does not allow for some vibration. If piping is too tight metal fatigue will occur.

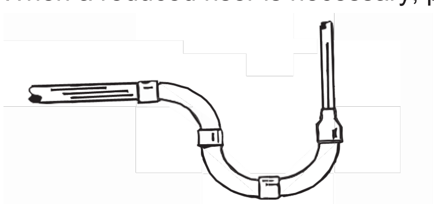


P-Trap Construction
P-traps must be installed at the bottom of all suction risers to return oil to the compressors to avoid trapping oil.



P-trap Construction

Reduced Riser
When a reduced riser is necessary, place the reduction coupling downstream of the p-trap.


Reduces Riser

Protecting Valves and Clamps
When brazing near factory installed clamps or valves be sure to protect them with a wet rag to avoid overheating. Insulate all reduced risers. Avoid using water or wet rags to cool a brazed joint. Allow brazed joints to air cool.

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

Elbows
Only use long radius elbows. Long elbows have been shown to have less pressure drop and greater strength. It is especially important to use long radius elbows for hot gas discharge lines.

Factory Supplied Stubs
Stub sizes provided from the manifolds do not automatically correspond to the line sizes necessary. It is the installer's responsibility to supply reduction couplings.

Flash Tank Safety Relief Valve
Safety relief valves must be properly vented in accordance with ASHRAE Standard 15 and applicable local codes.

Gas Cooler return lines should be free draining with no traps. All interconnecting valving to be field supplied and installed.

Protocol to Heat Reclaim
Refer to the instructions accompanying the system to be installed due to the variety of heat reclaim systems. Hussmann uses a 3-way valve.

Offset and Expansion Loop Construction

Inches of Linear Expansion per Length of Run

For low temperature applications, multiply the length of the run-in feet by 0.0169.

For medium temperature applications, multiply the length of the run-in feet by 0.0112.

Example 1:

Low temperature application, a run of 84 ft of 1 3/8 in. OD pipe.
84 ft x .0169 = 1.4196 inches of expansion

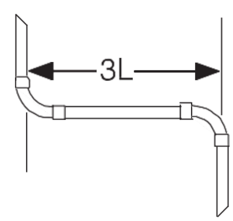
Select the smallest “Inches of Expansion” figure equal to or greater than the product in step one from the table below. Follow that column down until it intersects the OD line size of the run. The number listed at the intersection is the “L” valve for figuring offset an expansion loop size.

Equivalent Feet for Angle Valve and 90° Elbow				
Inches of Expansion				OD Line Size
0.5	1	1.5	2	
10	15	19	22	7/8”
11	16	20	24	1 1/8”
11	17	21	26	1 3/8”
12	18	23	28	1 5/8”
14	20	25	31	2 1/8”
16	22	27	32	2 5/8”
18	24	30	34	3 1/8”
20	28	34	39	4 1/8”

Example 2 (Offset Construction):

The smallest “Inches of Expansion” equal to or greater than 1.4196 is 1.5. The 1.5 column intersects with the 1 3/8” line at 21. Use “L” value 21. For an offset multiply the “L” value by 3 to determine the length of the offset.

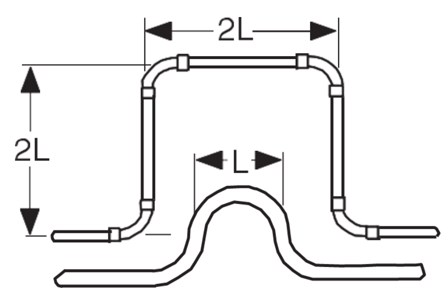
An “L” value of 21 would mean 3L = 3 X 21 or 3L = 63.



Example 3 (Expansion Loop Piping):

The offset distance required for low temperature application for an 84 ft run of 1 3/8” line is 63 inches. For an expansion loop, multiply the “L” value by 2 if hard copper and long radius elbows are used. If the expansion loop is formed in soft copper the loop diameter equals “L”.

For the same 84 ft run, a hard copper loop is 42 x 42 inches. A soft copper loop is 21 x 21 inches.



Application Notes

Do not exceed a straight run for 100 feet without a change in direction or construction of an expansion loop. Place an offset or loop in the middle of the run to minimize pipe shift and joint stress.

Sizing of all refrigerant lines is the responsibility of the installing contractor. Contact Hussmann Application Engineering if assistance is needed.

Branch Line Piping

Suction Line

Pitch in the direction of flow. Line size may be reduced by one size at one third of case run load and again after the second third. Do not reduce below evaporator connection size. Suction returns from evaporators and must enter at the top of the branch line.

Liquid Line (off-time and electric defrost)

May be reduced by one size after one half other case load run. Do not reduce below evaporator connection size. Take-offs to evaporators must exit from the bottom of the liquid line. Provide an expansion loop for each evaporator take-off. (minimum 3-inch diameter)

Copper Tubing Considerations

Due to the higher pressures required of transcritical R-744 (CO_2) systems, special copper tubing and fittings must be used in order to handle these higher head pressures. Design pressures of the various system segments will dictate the appropriate copper tubing type. All copper-to-copper brazed connections should use (as a minimum) brazing material that contains 15 percent silver (Sil-fos). All copper-to-steel connections should use 45 percent to 56 percent brazing material. During the brazing process, it is required to flow dry nitrogen within the piping to prevent oxidation and scaling.

WARNING: Always use a pressure regulator when operating nitrogen tanks.

Copper Tube and Fitting Pressure Rating

Product Line	*Product Type*	*Diameter*	
Copper Tube	Streamline ACR – Type L (Hard Lengths) Streamline ACR – Type K (Hard Lengths)	1/8″ – 1 3/8″ 1/8″ – 2 5/8″	UL Approved for 700 psi (48 Bar)
Copper Fittings	Streamline Wrot Solder-Joint Pressure	1/8″ – 2 5/8″	
Copper Tube	Streamline XHP 130 (CuFe2P)	3/8″ – 2 5/8″	UL Recognized to 1885 psi (130 Bar)

Insulation

Insulation should be used on CO_2 system piping to reduce the heat transfer to ambient air and to maintain sub-cooling in the CO_2 liquid line to the case. The insulation should be sized to allow for the worst-case conditions of heating from showroom lighting and ambient temperatures. To minimize the required insulation thickness, install pipe in air-conditioned space as much as possible. Do not size insulation for condensation prevention only. Pipe should be insulated according to local codes and customer specifications.

When installing piping that has not been pre-insulated, there are several options for insulation. Closed-cell elastomeric insulation is very popular in refrigeration applications. This type of insulation can also be used in secondary system applications.

For detailed information regarding elastomeric insulation visit the Armaflex website at: www.armaflex.com

Always follow the manufacturer's recommendations for insulation thickness and proper installation.

All suction lines and sub-cooled liquid lines must be insulated. CO_2 liquid in the liquid line will warm if the lines are left unprotected, resulting in energy loss. Over time this can lead to the liquid changing into a gas before it ever reaches the expansion valves. This is known as flashing. Flashing causes irregular flow through valves. If this occurs, significant refrigerant loss and poor energy performance will occur. Compressor motors will fail if the suction line gas is too warm as it enters the compressors. Insulate all CO_2 liquid lines and medium temperature suction lines with 1" wall, closed-cell insulation. Insulate all CO_2 low temperature suction lines with 1 1/2" wall, closed-cell insulation.

Pressure Relief Valves (PRV)

The Protocol includes multiple PRVs consisting of a dual port isolation valve fitted with two pressure relief valves for easy service. If a pressure relief gets stuck open even with the pressure at the normal operating range, it is recommended to change the secondary relief valve and replace the first one stuck open.

- The low temperature suction (low side) line is protected by 500 psig (35 bar) reliefs
- The medium temperature suction (intermediate side) line is protected by 600 psig (41.4 bar) or 652 psig (45 bar) reliefs depending on system configuration
- The flash tank (liquid line) is protected by 652 psig (45 bar) reliefs
- The medium temperature discharge (high side) line is protected by 1,740 psig (120 bar) reliefs

Pressure Relief Valve Key Terms

Change Over Valve

A change over valve is a three-way valve that allows for the technician to change the operation of one pressure relief valve to a secondary of back-up valve.

High-Pressure Relief

The high-pressure relief valve is the PRV device with the highest-pressure rating on the system. In typical systems this valve will have a relief rating of 1,740 psig (120 bar). This device is intended to protect the gas cooler and medium temperature discharge lines.

High Pressure Relief

The high-pressure relief is the PRV with a relief rating slightly above the operating pressure of the flash tank, medium temperature evaporators and circuits. In a typical system this PRV will have a relief value of 652 psig (45 bar). This device prevents damage to field piping, evaporators, flash tank, and medium temperature suction lines.

Low Pressure Relief

The low-pressure relief is the prv with the lowest pressure rating on the system which is above the low temperature suction pressure. In a typical system this PRV will have a relief value of 435 psig (30 bar). This device protects the low temperature evaporators and low temperature suction lines.

Important Installation Details

Pressure relief valves should not have piping installed downstream of the PRV. Installing piping after the valve may result in the formation of dry ice inside the pipe preventing the flow of relieved refrigerant gas.

Relief valves must be installed with the outlet of the valve facing down or to the side. Installation in another orientation will result in potential accumulation of water, ice, or snow preventing proper operation of the device.

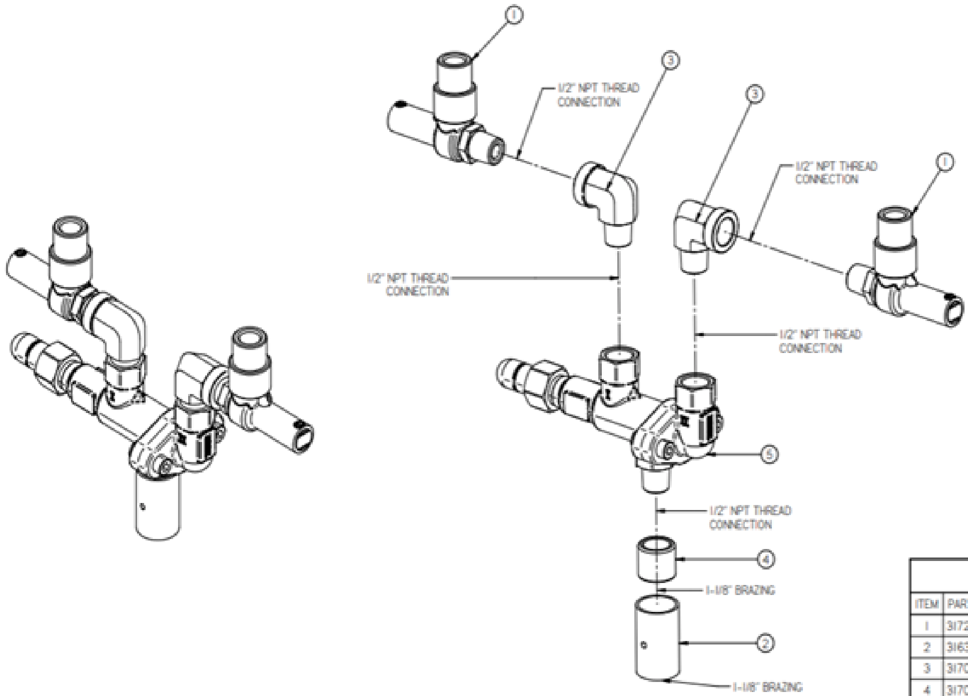
The pressure relief valves and accompanying parts are included in the ship loose package included with the system shipment.

Indoor installations require piping the relief devices outside of the machine room to prevent the possible accumulation of CO_2 inside an enclosed space.

Always consult local regulations for any additional requirements.

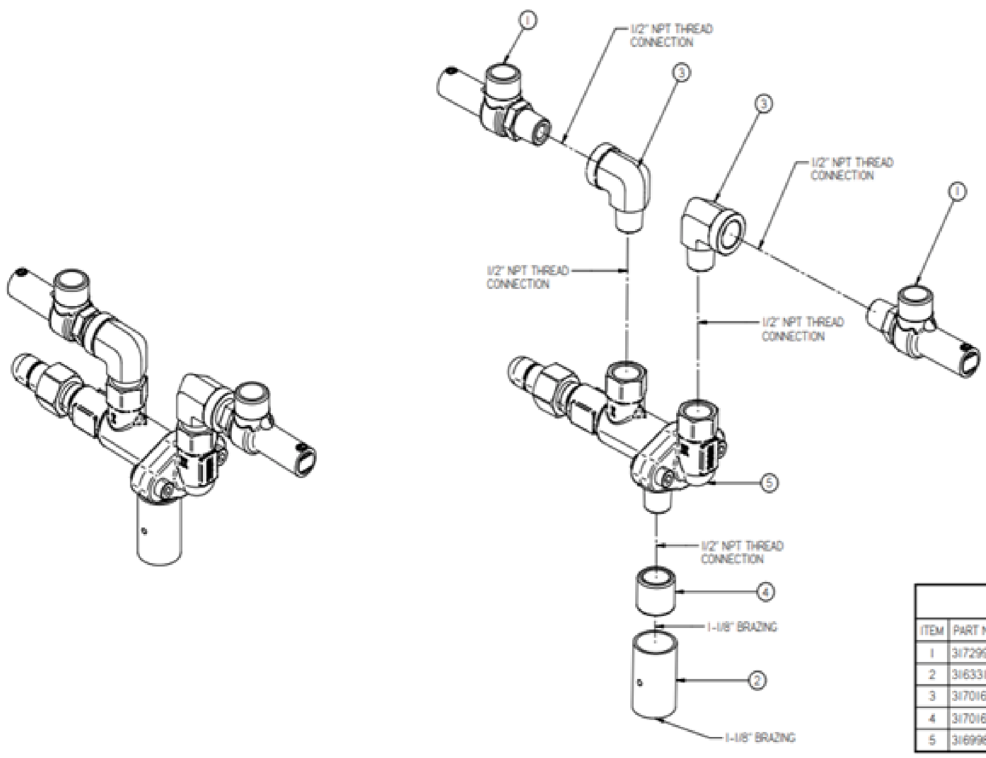
Protocol CO_2
Installation Information

500 psig (35 bar) Pressure Relief Valve



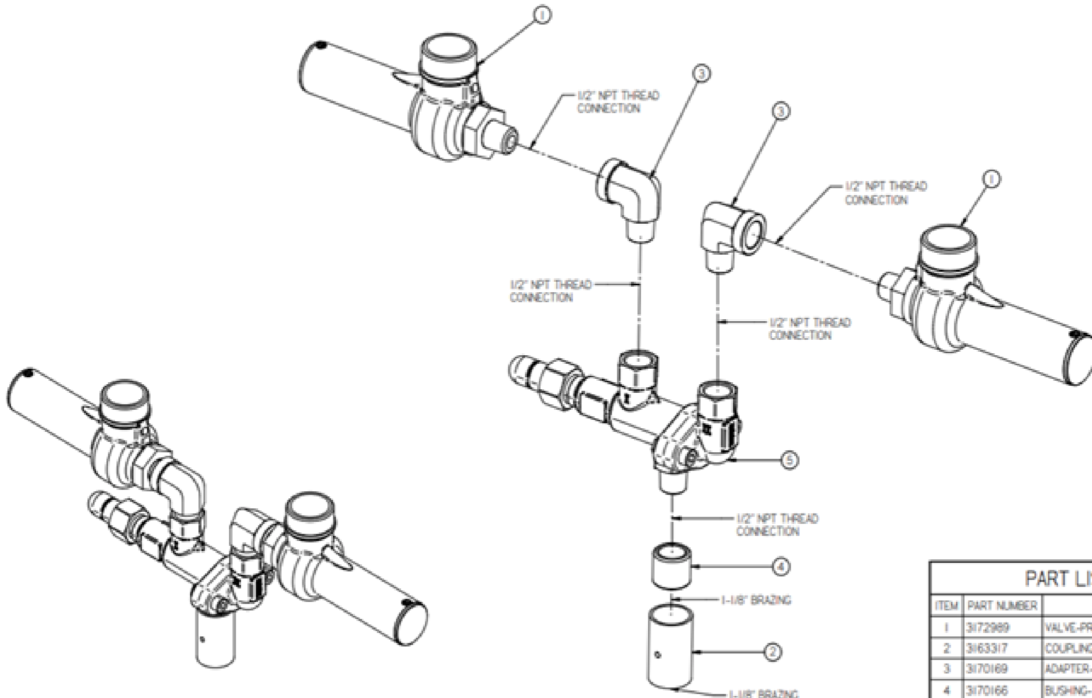
PART LIST - ASSEMBLY			
ITEM	PART NUMBER	TITLE	QTY
1	3172991	VALVE-PRESS RELIEF .500 NPTM X .750	2
2	3163317	COUPLING-STAKED-STOP C X C 1-1/8	1
3	3170169	ADAPTER-.500 NPT M X F 90 ELBOW	2
4	3170166	BUSHING-1-1/8 FTG X .50 FNPT FLUSH	1
5	3169980	VALVE-.500 NPT M X F 3 WAY CHANGEOVER	1

652 psig (45 bar) Pressure Relief Valve



PART LIST - ASSEMBLY			
ITEM	PART NUMBER	TITLE	QTY
1	3172990	VALVE-PRESS RELIEF .500 NPTM X .750	2
2	3163317	COUPLING-STAKED-STOP C X C 1-1/8	1
3	3170169	ADAPTER-.500 NPT M X F 90 ELBOW	2
4	3170166	BUSHING-1-1/8 FTG X .50 FNPT FLUSH	1
5	3169980	VALVE-.500 NPT M X F 3 WAY CHANGEOVER	1

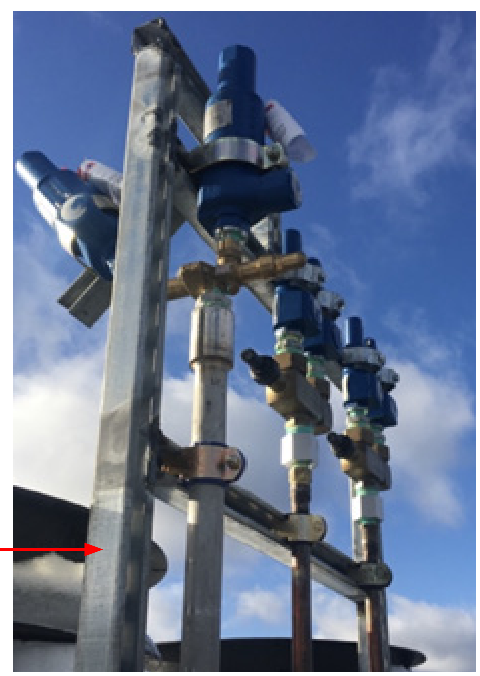
1,740 psig (120 bar) Pressure Relief Valve



PART LIST - ASSEMBLY			
ITEM	PART NUMBER	TITLE	QTY
1	3172989	VALVE-PRESS RELIEF .500 NPTM X 1.250	2
2	3163317	COUPLING-STAKED-STOP C X C 1-1/8	1
3	3170169	ADAPTER-.500 NPT M X F 90 ELBOW	2
4	3170166	BUSHING-1-1/8 FTG X .50 FNPT FLUSH	1
5	3169980	VALVE-.500 NPT M X F 3 WAY CHANGEOVER	1

Pressure Relief Valve Ports

Pressure Relief Ports



Unistrut or Equivalent (contractor provided)

Protocol CO_2
Installation Information

PRV Location and Installation

1. Locate the pressure relief ports on the system and identify the pressure for each port from the attached label on the assembly.
2. Identify the best location for the pressure relief devices based on your installation location. It is recommended that the devices are located in a manner to prevent discharge in the working areas for technicians.
   -Located on the roof above the machine room is ideal for indoor systems. Consider potential snow levels when choosing mounting height.
   -Top mount is an option for outdoor systems where the structure to support the PRVs can be affixed to the exterior of the system. This positioning keeps the relief valves away from technicians during service.

3. Using Unistrut or equivalent material construct an assembly to support the weight of the PRVs. When considering the construction, please allow for additional forces applied during a release of pressurized gas.
4. Once your support structure has been constructed and attached to a fixed surface, pipe the relief valve ports to the appropriate PRV. It is important that the correct pressure valve is attached to the appropriate port. Failure to do so will result in damage to the system or loss of charge.
   -Piping for the high pressure relief should only be done using copper-iron alloy (K65 & XHP) pipe. Failure to use the correct material on this relief valve will result in material failure of the pipe.
   -Piping for the high pressure and low pressure relief valves may be done in L-type ACR for sizes up to 1 3/8”.
5. Secure piping using appropriate clamps to the support structure to prevent damage from wind, snow, or pressure releases.
6. Install provided adapters and attach change over valve assembly to piping.
7. Install pressure relief valves onto the change over valves.
8. Once fully assembled, ensure the final mounting is secure.
9. Once system charging begins, verify that all connections and check valve outlets for potential leaks.

Copper Tubing

Included below is the Mueller pressure rating chart for Type-L & K ACR copper tubing to be used in low pressure 500 psig (34.5 bar) and either 600 psig (41.4 bar) or 652 psig (45 bar) relief valve assemblies (depending on system configuration. The below information provided is from Mueller Industries and is available on muellerstreamline.com

STREAMLINE® NITROGENIZED seamless copper tube is available in sizes 3/8" OD through 3-1/8" OD. Larger sizes from 3-5/8" OD through 8-1/8" OD are cleaned and capped. Manufactured and cleaned in accordance with ASTM B280. 20-ft. lengths hard drawn - cleaned and capped - color coded - Marked "ACR/MED"

TYPE K NITROGENIZED ACR / MED **RATED WORKING PRESSURE (PSIG)**

O.D. DIA.	WT/FT	150°F	200°F	250°F	300°F	400°F
3/8	0.145	913	877	860	842	537
1/2	0.269	960	923	904	885	565
5/8	0.344	758	728	713	698	446
3/4	0.418	700 †	700 †	700 †	577	368
7/8	0.641	700 †	700 †	700 †	668	426
1 1/8	0.839	700 †	700 †	700 †	513	327
1 3/8	1.04	700 †	700 †	700 †	416	266
1 5/8	1.36	700 †	700 †	700 †	387	247
2 1/8	2.06	700 †	700 †	700 †	341	217
2 5/8	2.93	700 †	700 †	700 †	312	199
3 1/8	4	500^	500^	500^	302	193
3 5/8	5.12	450^	450^	450^	286	183
4 1/8	6.51	450^	450^	450^	282	180
5 1/8	9.67	293	281	276	270	172
6 1/8	13.9	295	283	277	271	173
8 1/8	25.9	314	301	295	289	184

TYPE L NITROGENIZED ACR / MED

3/8	0.126	777	747	731	716	457
1/2	0.198	700 †	700 †	700 †	612	391
5/8	0.285	700 †	700 †	700 †	567	362
3/4	0.362	700 †	700 †	700 †	496	316
7/8	0.455	700 †	700 †	700 †	457	292
1 1/8	0.655	700 †	700 †	700 †	388	248
1 3/8	0.884	700 †	700 †	700 †	344	220
1 5/8	1.14	650^	650^	650^	320	205
2 1/8	1.75	550^	550^	550^	285	182
2 5/8	2.48	500^	500^	500^	263	168
3 1/8	3.33	450^	450^	450^	249	159
3 5/8	4.29	450^	450^	450^	238	152
4 1/8	5.38	400^	400^	400^	230	147
5 1/8	7.61	229	229	215	211	135
6 1/8	10.2	213	213	201	196	125
8 1/8	19.3	230	230	216	212	135

Tables give computed allowable stress at indicated temperatures for copper tube that has been annealed either through brazing or an annealing furnace.

† UL Recognized to 700 PSI (select sizes)
^ Rated in accordance with UL 207 Performance Testing

A BRAND OF MUELLER INDUSTRIES

Start-Up Sheet

All setpoints are to be on a setup sheet mounted inside the door of the Protocol's electrical cabinet. This sheet includes all setpoints for field-adjusted components. (e.g., suction pressure, discharge pressure, flash tank pressure setting, etc.)

HUSSMANN REFRIGERATION SYSTEMS

Hussmann Refrigeration Equipment CO2 Commissioning Sign Off Sheet

All sections of this document must be completed before the installation will be accepted.

General Information

Store Name :	Store #:
Location (street, city, state, zip):	
Protocol Model # :	Protocol Serial # :
Start-up date :	Commissioning date :
Installing contractor :	
Address :	
Phone # :	
E-mail address :	

INSTALLATION APPROVAL

The work carried out during this project is complete, and the standard achieved is acceptable.

Customer Representative

Signature	Date

Refrigeration Contractor

Signature	Date

Hussmann Corporation • Bridgeton, MO 63044-2483 U.S.A. • www.hussmann.com
U.S. & Canada 1-800-922-1919 • Mexico 800-890-2900

Protocol CO_2
Installation Information

By signing this form, you are confirming that the work detailed below is complete, and that all systems are operating as intended. All handover documentation has been completed, and you are satisfied with their contents.
All issues are either resolved and/or you are satisfied with the plan for resolution.

Compressors manufacturer / low temp: ______________________

Compressors manufacturer/ medium temp: Type of oil ______________________

used:

Compressor # (ex. 1/+20)		Model #	Serial #
Compressor #	1		
Compressor #	2		
Compressor #	3		
Compressor #	4		
Compressor #	5		
Compressor #	6		
Compressor #	7		
Compressor #	8		
Compressor #	9		
Compressor #	10		

Compressor # (ex. 1/+20)		CC Heater (amp)	Net oil pressure	High pressure cut in and cut out setting	Voltage L1-L2	Voltage L1-L3	Voltage L2-L3	Amperage L1	Amperage L2	Amperage L3
Compressor #	1									
Compressor #	2									
Compressor #	3									
Compressor #	4									
Compressor #	5									
Compressor #	6									
Compressor #	7									
Compressor #	8									
Compressor #	9									
Compressor #	10									

Protocol Checklist

Is the Protocol placed on anti-vibration pads?	Yes	No
Is leak detection installed?	Yes	No
If so, has it been tested, certified and functional?	Yes	No
Is there an alarm or screen on entrance of compressor room indicating the CO2 PPM?	Yes	No
Is proper signage on compressor room?	Yes	No
Do all exhaust fans operate correctly?	Yes	No
Are all Protocol panels closed?	Yes	No
Was the system under pressure upon reception?	Yes	No
If not, has Hussmann been notified?	Yes	No
Are all check valves in place per the engineering diagram?	Yes	No
Has the flow direction of all check valves been verified per engineering piping diagram?	Yes	No
Refrigerant grade (grade must be Bone Dry or higher):		
Refrigerant charge (LBS):		
Is the refrigerant the same as indicated on the Protocol's name plate?	Yes	No

Protocol CO_2
Installation Information

Electrical				
Control system manufacturer:				
Verify the control voltage	L1>GD			
	L2>GD			
	L1>L2			
Verify all electrical connections are tight: (performed by contractor, prior to startup)	Yes		No	
CO_2 Swagelok outlet oil pressure setting if applicable:			PSIG	
High Pressure Alarm Setting:			PSIG	
Suction Groups				
Low Temp				
Check and record the Protocol suction pressure:	EMS		Gauge	
Check and record the Protocol suction temperature:	EMS		Meter	
Check and record the Protocol suction superheat temperature:	EMS		Meter	
Confirmed calibration of EMS discharge transducer?:	Yes		No	
Check and record the Protocol discharge pressure:	EMS		Gauge	
Check and record the Protocol discharge temperature:	EMS		Meter	
Medium Temp				
Check and record the Protocol suction pressure:	EMS		Gauge	
Check and record the Protocol suction temperature:	EMS		Meter	
Check and record the Protocol suction superheat temperature:	EMS		Meter	
Confirm calibration of EMS discharge transducer?:	Yes		No	
Check and record the Protocol discharge pressure:	EMS		Gauge	
Check and record the Protocol discharge temperature:	EMS		Meter	
Check and record the condenser drop-leg temp or gas cooler return:	EMS		Meter	

Misc.		
Is there heat reclaim?	Yes	No
What type of heat reclaim?		
Heat reclaim control settings (cut in/cut out)		
Is surplus C02 available on the site?	Yes	No
If so, how many lbs.?		
Does this Protocol have sub-cooling?	Yes	No
Liquid (sub cooling) temperature set point.	DegF	
Liquid temperature:	DegF	
Note Flash gas bypass valve setting (acceptable range 520 - 610 psig for flash tank)?		
Is the gas cooler / condenser clean and free of debris?	Yes	No
Gas cooler / condenser fans have the correct rotation?	Yes	No
Is there a VFD controlling the fans on the gas cooler: First Pair	Yes	No
Is there a VFD controlling the fans on the gas cooler: All	Yes	No
Confirm correct settings / operation of VFD?	Yes	No
Has gas cooler throttle valve been set if applicable?	Yes	No
What type of piping used for the gas cooler / condenser?		
Confirmed operation of flash tank alarm device?:	Yes	No
Level of refrigerant in flash tank, at what ambient temperature?	%	DegF
Caps are on, and tightened at end of start-up?	Yes	No
Confirm that there is enough oil in the oil reservoir?	Yes	No
Confirm the oil level in each compressor is correct per the mfg. recommendation?	Yes	No
Has the operation of the OMC been verified?	Yes	No
Has the oil been changed after start up?	Yes	No
Are all the relief valves well fastened?	Yes	No
Has the oil level alarm been functionally tested?	Yes	No
Does the battery backup close the suction stops on the Protocol when a power loss occurs...if applicable?	Yes	No
Notes :		

Evacuation

WARNING: Always use a pressure regulator when operating nitrogen tanks.

CAUTION: Never trap liquid refrigerant between closed valves as this could cause a hydraulic explosion.

Nitrogen and moisture will remain in the system unless proper evacuation procedures are followed. Nitrogen left in the system may cause head pressure problems. Moisture causes EEV ice blockage, wax build up, acid oil, and sludge formation.

Do not simply purge the system. This procedure is expensive, harmful to the environment, and may leave moisture and nitrogen behind.

Do not run the compressors to evacuate. This procedure introduces moisture into the compressor's crankcase oil and does not produce adequate vacuum to remove moisture from the rest of the system at normal temperatures.

R-744 (CO_2) Protocol Evacuation / Charging

CO_2 has a low tolerance for moisture so care should be taken to evacuate the system before charging (similar to synthetic refrigerants). Ensure all individual line tests have been completed and all the nitrogen has been removed before completing the vacuum process. Using the correct pump (minimum of 10 CFM) and technique for the vacuum to obtain the target of 70 microns. Of course, the Protocol will also need to be evacuated and put under vacuum before charging.

The triple evacuation method should be used to achieve a leak-free, dry system. For the first evacuation, the system should be pulled down to 1,000 microns. The second evacuation should be pulled to 500 microns. The final evacuation should be pulled down to at least 300 microns. A dry, leak-free system is when the system holds a vacuum of 300 microns for 24 hours with the vacuum pump de-energized and valved off. Between each evacuation, break the vacuum with dry nitrogen.

Use a copper manifold to join the connections on the high, intermediate, and low side simultaneously. Ensure that the connections to the vacuum pump can be manually isolated.

A maximum of two vacuum pumps will be allowed, adding up to at least 10 CFM. However, it is preferable to use a single vacuum pump, capable of at least 25 CFM. It is important that the oil in the pumps be changed regularly until the micron level has been reached:

- 1st oil change after first evacuation
- 2nd oil change after second evacuation

A few things should be considered when starting the vacuum process:

- Ensure the system is 100% free of leaks.
- All the connections from the vacuum pump to the Protocol should be soft drawn copper lines 5/8”.
- Ensure the connections have been tested before starting the pump.
- All the caps on the Protocol and in the cases need to be installed and tightened.
- All the valve packings need to be tightened.
- Ensure liquid filters are installed before starting the third vacuum.
- Crankcase heaters should be turned on.

It is important to note that a low vacuum pulled on transducers may damage the sensor. Consult with the sensor manufacturer to determine if the transducer should be isolated during these conditions.

It is important that the start-up sheet be filled out and a picture of the gauge indicating 300 microns (hold for 24 hours) be kept for records.

R-744 (CO_2) Protocol Evacuation / Charging (cont.)

The vacuum on the system should be broken using CO_2 vapor tanks to a pressure of 100 psig to prevent the formation of dry ice, as described in this manual. Liquid may be used to charge the system once the pressure is above 100 psig. Enough CO_2 should be available on site in both liquid tanks and vapor tanks to fully charge the system. The CO_2 should be Refrigerant Grade (99.99% purity) or better.

Note: After pressurizing the system to 100 psig, back seat the MT discharge compressor valve to fill the MT compressor discharge relief lines with CO_2 gas.

- Be sure not to fill the FT above the third site glass.
- Open compressors—open service valves on suction and discharge.
- Open oil supply line immediately downstream of the oil separator and reservoir.
- Pressure transducers—open angle valves.
- Leave open ball valves—to branches, gas cooler, heat reclaim, and flash tank.
- Set all mechanical pressure controls.
- During the last evacuation, look up and make a list of the required control settings for the system.

Low Pressure Controls

Compressor low pressure controls are field set. Consult your Hussmann factory representative for setting parameters and operational criteria.

Pre-Charge Checklist

While the system is being evacuated, preparation for charging can begin. During any of the pull downs check the following:

- Merchandiser’s electrical requirements and power supply electrical connections are tight and clean
- Check for proper fan operation and case controller settings
- Walk-in coolers and freezers electrical requirements and power supply
- Damper operation, if equipped
- Heat reclaim and other systems

Control Checks

During the duration of filling the flash tank, all mechanical controls should be set—low pressure switch and verify oil failure at the compressor and oil separator and reservoir.

Low pressure controls should be set below the Protocol setpoint. They should be verified with a set of gauges and close the suction stems to verify each control will cut out.

Each control should display an alarm in the controller when each test is complete.

Leak Testing

Leaks can be very costly over time. It is very important to follow EPA Greenchill Installation Leak Tightness Guidelines as well as Greenchill Leak Prevention and Repair Guidelines. Ensure all compressor control ON-OFF switch are in the OFF position.

Do not start any compressors without ensuring there is oil in them. Serious damage to the compressors may result from not having oil in them.

Always use a pressure regulator with a nitrogen tank. Do not exceed two pounds of pressure and vent lines when brazing. Do not exceed 1,400 psig (96.5 bar) for leak testing the transcritical high side. Do not exceed 350 psig of pressure for leak testing the subcritical low side.

Isolate all pressure transducers during vacuum and pressure testing.

All refrigeration lines under the floor should be leak and pressure tested and inspected prior to backfilling. All underground lines should be pressurized to 350 psig and held for 24 hours. It is recommended to test piping before tying in the cases. If any leaks are found, isolate the leaks, discharge the gas and repair the leaks, and then repeat the test. This general method is not different from any other synthetic refrigeration system.

Field pressure testing is done both for leak testing and for the pressure rating of a system. It is possible to check for leaks at a lower pressure, but codes dictate that the system be proven tight at the system design pressures. For CO_2, the LT suction lines and evaporators are rated for 500 psig (34.5 bar) and the high side (including MT suction lines and liquid lines) are rated for 600 psig (41.4 bar). Also, check to see if there are any specific job pressure testing requirements that might require higher pressure testing.

The pressure test schedule below should be used as standard guidance:

Pipe Section	Test Pressures
LT Suction	350 psig (24.1 bar)
MT Suction / Liquid	525 psig (36.2 bar)
MT Discharge / Drain	1,400 psig (96.5 bar)

Oil Levels

Check oil levels for each compressor and the oil reservoir. Compressor sight glass should be at 1/8 to 1/2 full, oil reservoir bottom sight glass filled. See legend for oil types used in CO_2 Protocol system.

If the oil is low, add the appropriate oil or lubricant to match the compressor used. Consult the compressor manufacturer for the correct oil type per the given application.

Final Checks

Once the Protocol is up and running, it is the responsibility of the installer to see that all the fine adjustments are made so the Protocol delivers maximum temperature performance and efficiency for the customer.

Adjustments may include:

- Defrost scheduling and timing
- Gas cooler controls
- Case controller adjustment

Pre-Startup Checklist

Piping, Evacuating, and Charging

- ☐ All field-installed piping completed, including cases, walk-ins, gas cooler, heat reclaim, etc.
- ☐ Remotely mounted relief valves should be installed per the installation details.
- ☐ All piping should be pressure tested per local codes.
- ☐ The system should be evacuated as described in this manual.
- ☐ The vacuum on the system should be broken using CO_2 vapor tanks to a pressure of 100 psig to prevent the formation of dry ice, as described in this manual. Liquid may be used to charge the system once the pressure is above 100 psig. Enough CO_2 should be available on site in both liquid tanks and vapor tanks to fully charge the system. The CO_2 should be Refrigerant Grade CO_2 (99.9% purity) or better.
- ☐ Verify that all filters are installed on the rack, including the oil separators, suction filters, and liquid driers (field installed).
- ☐ The oil reservoir should be filled with the oil specified by the compressor manufacturer; ZEROL RFL 68EP (PAG oil) only. Enough oil should be available on site for the initial startup and first oil change.

Protocol

- ☐ All electrical connections in the Protocol control panel are properly tightened.
- ☐ Main power and control power is on, and the voltage is correct.
- ☐ All Protocol control boards are online and communicating with the Protocol controller.
- ☐ All Protocol temperature sensors are reading correctly in the Protocol controller.
- ☐ All Protocol pressure transducer shut-off valves are open, and the transducers are reading correctly in the Protocol controller.
- ☐ Compressor crankcase heaters should be turned on 24 hours prior to system start up.
- ☐ There should be a minimum of 40% of the Protocol evaporator load (both MT and LT) available for the initial startup of the system.

Gas Cooler

- ☐ All electrical connections in the gas cooler control panel are properly tightened.
- ☐ Power is on and the voltage is correct.
- ☐ Verify that the gas cooler fan staging, speed control, and rotation are correct.
- ☐ Adiabatic gas coolers should have the water turned on and drain lines completed.
- ☐ Gas cooler outlet temperature sensor(s) should be installed, insulated, and wired to the Protocol controller per the installation details.
- ☐ All control wiring for the gas cooler operation is installed as required. This may include wiring for communication, fan speed reference, fan staging, ambient temperature, adiabatic pre-coil temperature, alarm/status outputs, etc. See installation details for specific requirements.
- ☐ The gas cooler temperature sensor(s) are reading correctly in the Protocol controller.
- ☐ If equipped, the control boards installed in the gas cooler are online and communicating with the Protocol controller.

Cases and Walk-ins

- ☐ All case controller communication wiring should be complete.
- ☐ The power for the cases and walk-in evaporator coils should be turned on.
- ☐ All case controllers should be addressed and communicating with the Protocol controller.
- ☐ All temperature sensors on the cases and walk-in evaporator coils are reading correctly in the case controllers.
- ☐ All pressure transducer shut-off valves are open, and the transducers are reading correctly in the case controllers.
- ☐ Verify operation of all case and walk-in evaporator coil fans.
- ☐ The case drain lines or evac system should be completed.
- ☐ All penetrations should be sealed.
- ☐ The case controller programming in the rack controllers is complete.
- ☐ The walk-in leak detector system must be operational.

Other

- ☐ Verify that the machine room leak detection and ventilation are functional.
- ☐ All work areas represent a safe work environment and are free of construction debris.
- ☐ The customer or contractor must provide competent personnel with proper tools and equipment and be present on-site for the entirety of the FQS visit.
- ☐ If equipped, the backup condensing unit and generator should be installed and operational.

Startup Procedure

Once the controls have been set and the flash tank is filled to the required level (do not exceed 565 psig), the medium temp (MT) must be started first.

Once there is enough load to keep the Protocol running, look at all the amperages on all compressors. Record this data for future reference (can be written on the control panel).

Startup Sequence

1. Prior to starting the Protocol up or putting power to the Protocol, make sure all the electrical connections in the Protocol panels and compressors are tight. All case controller panels for all coolers, freezers, and cases should be checked.
2. At least 40% of the Protocol evaporator load (both MT and LT) should be available prior to Protocol startup.
3. Several tests should be performed on the Protocol prior to running. (Note: Control must be powered up)
   - Perform a phase loss test to make sure all the case controller EEVs shut down
   - Once the phase loss is reset, all the case controllers should return to normal
   - Leak detection in all walk-in boxes and mechanical rooms must be tested, and fully functional—the exhaust fan should be in operation prior to charging of the system
   - It is not recommended for leak detection to shut down the Protocol as this may result in additional CO_2 being released to the atmosphere
4. Check the system operating temperatures and defrost time. The length and number of defrost cycles must be set in accordance with case manufacturers' recommendations and the owner/operators defrost guidelines.
5. A final defrost schedule must be provided to the store manager during the week of grand opening as well added to the door of the Protocol. All work within start-up procedure needs to be recorded in a logbook kept in the motor room.
6. After the compressor is started, continue charging until the system has sufficient refrigerant for proper operation. During start-up, no compressor is to be left operating unattended and unwatched until the system is properly charged with refrigerant and oil.
7. After the system has been in operation for a minimum of seven days, all expansion valve strainers must be cleaned and is recommended for valves with removable screens.

NOTE For new construction, it is recommended that all freezer boxes are set at 35° F (1.7° C) and run for a minimum of 48 hours, then drop to 10° F (-12.2° C) for 24 hours. This will pull the moisture out of the floor in the freezers. Afterward, if the customer has a requirement or specification, follow it.

Monitor the Following:

- Flood back
- Monitor oil levels in the oil reservoir and well as in the compressor crankcase
- Monitor flash tank pressure to ensure it never exceeds 600 psig (41.4 bar)—if so, review operation and set points
- It is recommended to place the filters back in the suction shell
- Flash tank pressure must be 80 psig above the medium temp suction pressure to ensure oil flow to the compressors

After Startup

Oil and Filter Replacement

1. Charge the Protocol fully with oil. After the Protocol is full, it is recommended to change the suction, liquid and oil filters within 30 days or as required by the customer's specifications. Hussmann supplies filters for startup and enough for one change after startup.
2. Additional oil changes may be needed based on customer-specific requirements and to ensure the unit is clean.
   NOTE: Any time the system is opened after this point, the drier cores must be replaced.
3. Leak test with a CO_2 sniffer type tool, such as D-Tek CO_2 refrigerant leak detector.
4. Defrost lengths and pressures should be verified to ensure that energy consumption is at a minimum.
5. Always check that each post-defrost case temperature exceeds 32° F (0° C) in the evaporator and the coil is clear.
6. If the coil is not clearing using the recommended defrost settings, call the case manufacturer for review.
7. Ensure that all the programming is finished and well understood by the servicing contractor.
8. Ensure that all temperature sensors and pressure sensors are well calibrated.
9. Ensure all control panels are closed.
10. Record CO_2 level in the flash tank for future reference.
11. Fill out startup form and send to Hussmann a maximum of three weeks after initial startup.

Thermostat Settings

1. Thoroughly inspect all field piping while the equipment is running and add supports where line vibration occurs. Be sure additional supports do not conflict with pipe expansion and contraction.
2. When merchandisers are completely stocked, check the operation of the system again.
3. At 90 days, recheck the entire system, including all field wiring. Future maintenance costs may be reduced if an oil acidity test is run at this time. Replace acidic oil.

Sequence of Operation

The Protocol CO_2 sequence of operations establishes control objectives, recommendations, and standard operating parameters for a refrigeration system. The system is capable of running in low and high ambient conditions.

For the purposes of this sequence, the Protocol CO_2 is comprised of a multiple number of MT and LT compressors on common suction headers. The LT compressors discharge into the MT suction header and the MT compressors discharge into a coalescing oil separator. All compressors are fed from a common oil reservoir maintained at flash tank pressure. Other components typically found on a booster system: suction filters, liquid driers, compressor oil level controls, flash tank, liquid-suction heat exchangers, suction accumulators, liquid and hot gas injection, high pressure valve, and flash gas bypass valve. Unlike traditional booster systems, the Protocol CO_2 utilizes ECO-DV, which is the use of an economizer heat exchanger and vapor injection into the medium temperature scroll compressors. A heat reclaim valve is optional.

The specific functions in which this sequence will control are:

- Compressor staging
- System operation
- Compressor variable capacity
- Pressure relief valves
- Oil management
- Circuit stage-up (auto restart after power failure)
- Heat reclaim operation
- Gas cooler fan control
- High pressure valve, economizer, and flash gas bypass valve
- Valve controls (e.g., hot gas, liquid, vapor injection, etc.)
- Phase loss

Typical Input and Output Points

Analog Output – VFD or Digital Unloader (Modulating Compressor Capacity)

Analog Output – Gas Cooler Fan Speed

Analog Output – Oil Solenoid SSR

Relay Output (N.O.) – Compressor On (1 per compressor)

Relay Output (N.O.) – Hot Gas Injection Superheat Solenoid

Relay Output (N.O.) – Liquid Injection Solenoid

Digital Input (N.O.) – General Compressor

Alarm Digital Input (N.O.) – Compressor VFD

Alarm Digital Input (N.O.) – Oil Fail (1 per compressor)

Digital Input (N.O.) – Phase Loss

Digital Input (N.O.) – Low Liquid Flash Tank

Digital Input (N.O.) – Oil Separator High Alarm

Analog Input – Suction Pressure (per suction group)

Analog Input – Suction Temperature

Analog Input – Compressor Run Proof (1 per compressor)

Analog Input – Discharge Pressure

Analog Input – Discharge Temperature

Analog Input – Protocol Leak Detector

Analog Input – Gas Cooler Outlet Pressure

Analog Input – Gas Cooler Outlet Temperature

Analog Input – Flash tank Pressure

Analog Input – Ambient Temperature

Analog Input – Pad Temperature

Stepper Output – High Pressure Valve

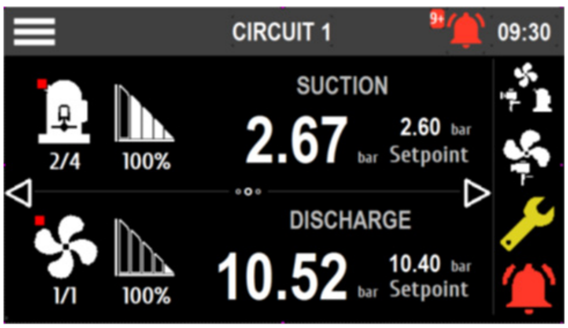
Stepper Output – Flash Gas Bypass Valve

Stepper Output – Economizer Valve

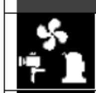
XC-Pro Controller Navigation

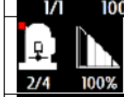
The XC-Pro can be connected to remote touch panel VISOTOUCH, where the main variables and status are being displayed and the user can set up the system. After turning ON the unit, touch the panel to enter in the main screen visualization.

Main Screen Visualization

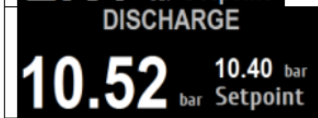
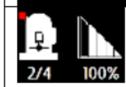
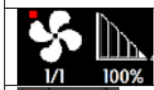
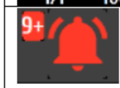


Navigation Icons

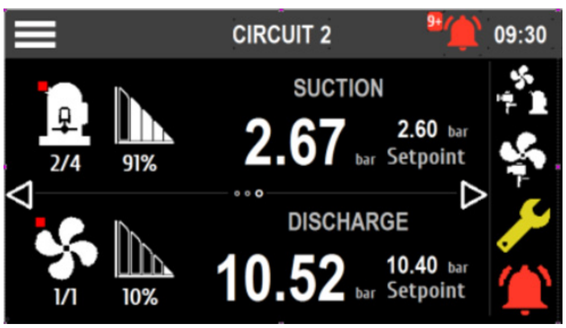
	Go to GENERAL MENU
	Go to SCHEMATIC page
	Go to GAS COOLER page
	Go to SERVICE page
	Go to ALARM page
	Go to CIRCUIT 2 if present

	Go to GAS COOLER page
	Go to COMPRESSORS page
 or 	Go to SET POINT page
	Go to ALARM page

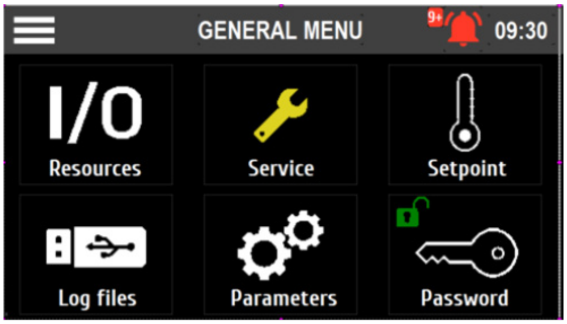
Icon Meanings

	Circuit 1 (MT) Suction Pressure (temperature) value and Suction Set Point
	Gas Cooler Pressure Value and Gas Cooler Set Point (always in temperature)
	Number of compressors running/available in Circuit 1 (MT) and VSD Compressor speed %
	Number of fans running/available and Fan speed %
	Icon presents only if there is one or more alarm(s) active. The number from 1 to 9+ is for the number of alarms active
	The icon is white if there are no alarms active

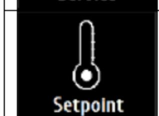
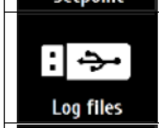
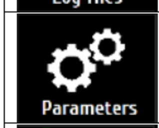
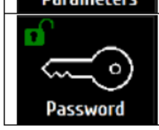
The above information is also true for CIRCUIT 2 (LT) page if it is present.



General Menu



<u>Navigation Icons</u>

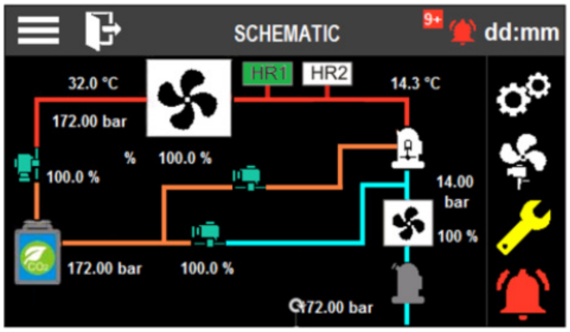
	Go to **I/O** page
	Go to **SERVICE** page
	Go to **SET POINT** page
	Go to **LOG FILE** page
	Go to **PARAMETER** page
	Go to **PASSWORD** page

Protocol CO_2
Operation and Controller

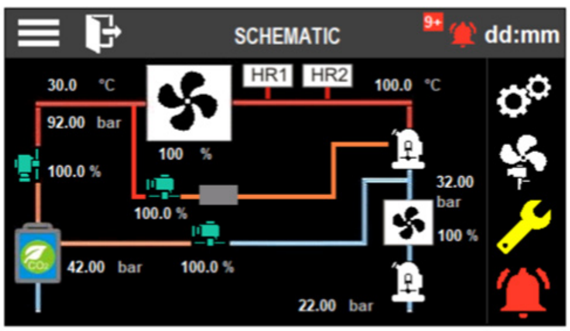
Schematic

According to the configuration the following schematic will be displayed.

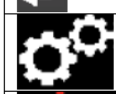
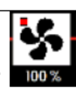
<u>Open Flash Tank DVI</u>



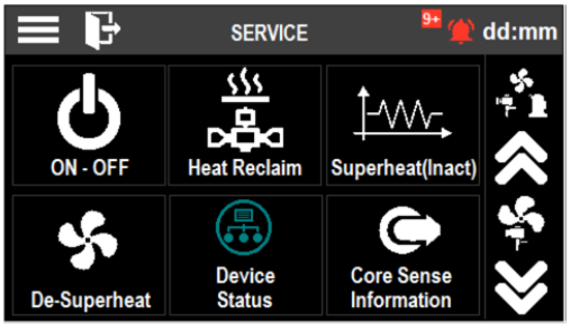
<u>Economizer DVI</u>



Icon Navigation

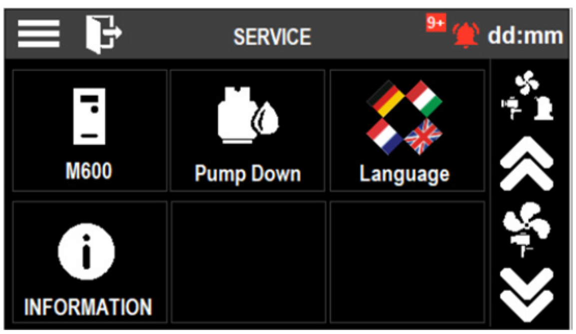
	Go to **MAIN** page
	Go to **PARAMETER** page
 or  or 	Go to **GAS COOLER** page
	Go to **ECONOMIZER** page
	Go to **TEMPERATURE SUCTION LINE** page
 or 	Go to **HEAT RECLAIM** pages

Service



On-Off	Go to **ON – OFF** page	De-Superheat	Go to **De-Superheater** page
Heat Reclaim	Go to **Heat Reclaim** page	Device Status	Go to **Device Status page**
Superheat	Go to **Suction Superheat** page	Core Sense Information	Go to **Core Sense** page

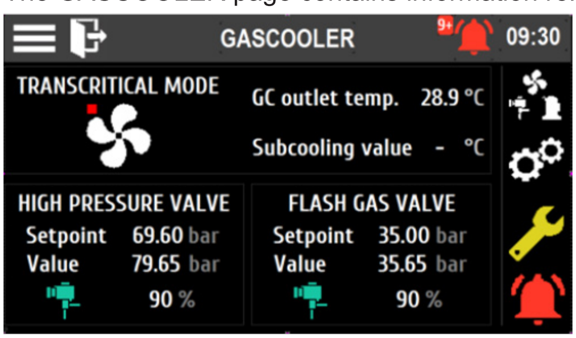
Energy Meter Status	Go to **Energy Meter Status** page	Core Sense Setup	Go to **Core Sense Setup** page
Conf File Management	Go to **Configuration File Management** page	Real Time Clock	Go to **Real Time Clock** page
Conf IP & MDB Address	Go to **Configuration IP & Modbus Address** page	Energy Saving	Go to **Energy Saving** page



M600	Go to **M600 Inverter Status** page	Pump Down	Go to **Pump Down** page
Language	Go to **Language** page	INFORMATION	Go to **Information** page

Gas Cooler

The GASCOOLER page contains information related to the gas cooler and flash tank.

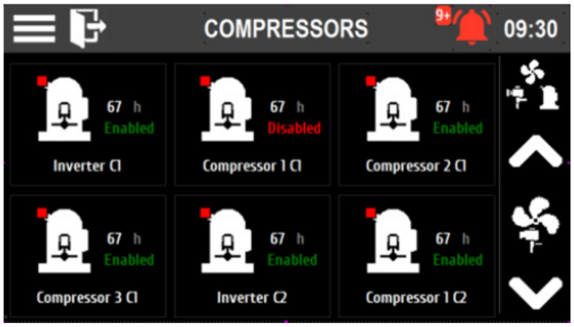


<u>Navigation</u>

90 %	Go to page VALVE OVERRIDING to override HPV value	90 %	Go to page VALVE OVERRIDING to override BPV value

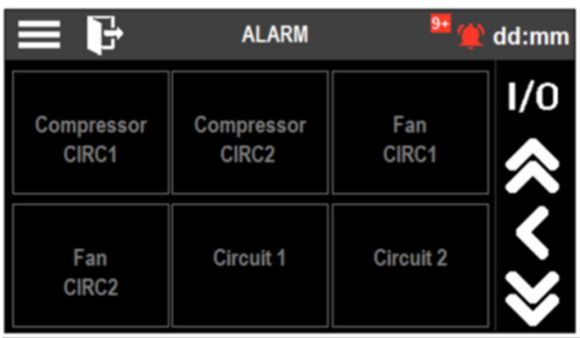
Compressors

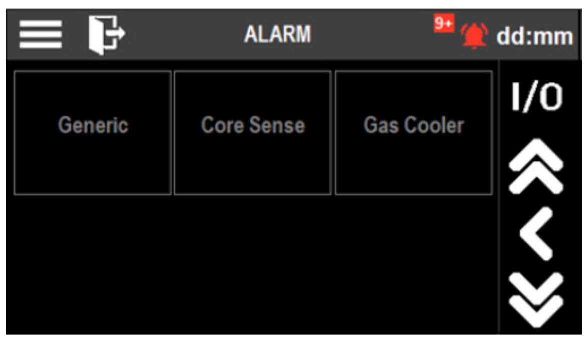
This page is visible only if there is more than one compressor enabled. The number of compressors displayed is according to the real number of compressors present. The compressors are identified as C1 for circuit 1 (MT) and C2 for circuit 2 (LT).



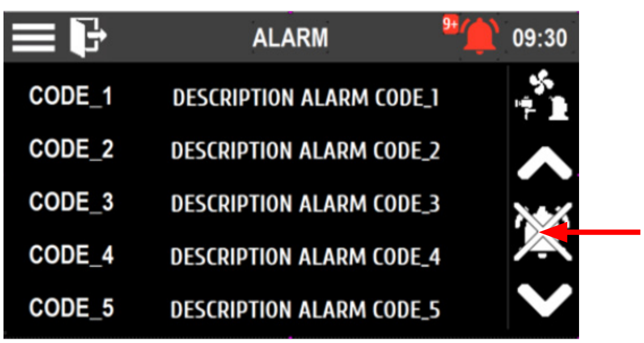
Alarms

To help the navigation among the alarms, the alarms are divided in several menus. When an alarm is active, the correspondent menu is flashing. Touch the active menu to see which alarm is active.





The alarm menu has the following structure:

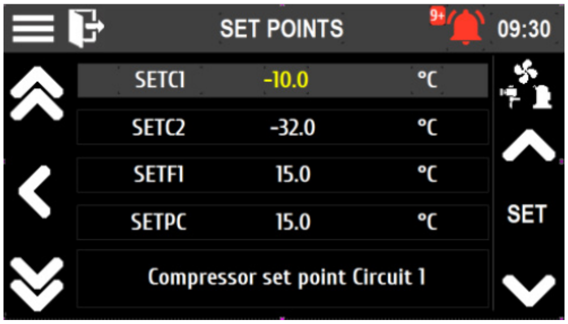


Alarm reset:

White if alarm not resettable
Red if alarm resettable

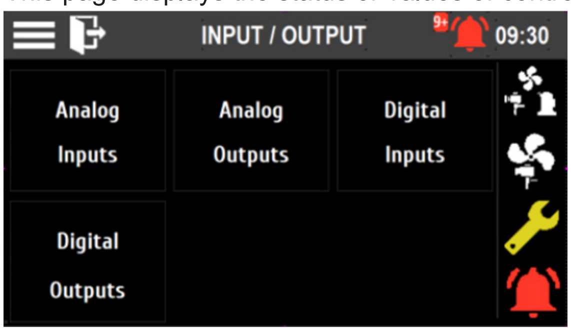
Set Points

Use the UP and DOWN arrow to scroll among the set point list. Use SET to select a parameter and to confirm a parameter value.

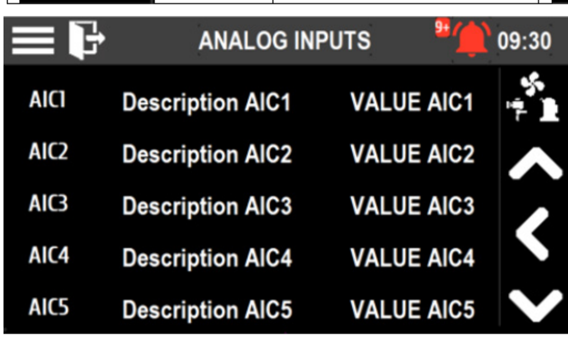


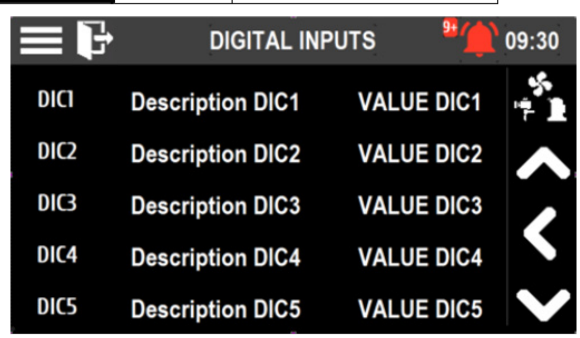
I/O Page

This page displays the status or values of controllers I/Os.



Analog Inputs		Go to **ANALOG INPUTS** page	Digital Inputs		Go to **DIGITAL INPUTS** page
Analog Outputs		Go to **ANALOG OUTPUTS** page	Digital Outputs		Go to **DIGITAL OUTPUTS** page





XP Pro Alarm List

Medium Temperature Stage (Circuit 1) Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
LP1	low-pressure switch alarm for circuit 1	low pressure switch input 1 (the Input is configured as DICxx=101 low pressure circuit 1)	All compressors of circuit 1 are turned off, fans unchanged	**Automatically** if the number of activations are less than AL12 in the AL13 time when the input is disabled **Manually** if AL12 activation happened in the AL13 time when the input is disabled: turn the instrument off and on or reset the alarm manually from the Visotouch *Compressors restart working according to the working algorithm*
HP1	high-pressure switch alarm for circuit 1	high pressure switch input 1 (the Input is configured as DICxx=99 high pressure circuit 1)	All compressors of circuit 1 are turned off, all fans of circuit 1 are turned on	**Automatically** if the number of activations are less than AL29 in AL30 time when the input is disabled. **Manually** if AL29 activation happened in the AL30 time when the input is disabled: turn the instrument off and on or reset the alarm manually from the Visotouch *Compressors and fans restart working according to the working algorithm*
LAC1	minimum pressure (temperature) compressors alarm for circuit 1	If AC1 = REL: suction pressure or temperature ≤ SETC1-AL3 If AC1 = ABS	Only signaling	**Automatically** as soon as the pressure or temperature reaches: If AC1 =REL

Code	Description	Cause	Action	Reset
LAF1	minimum pressure (temperature) fans section alarm for circuit 1	IfAC2 = REL: condenser pressure or temperature ≤ SETF1-AL24 for timer AL26 IfAC2 = ABS: condenser pressure or temperature ≤ AL24 for timer AL26	Only signaling	**Automatically** as soon as the pressure or temperature reaches: IfAC2 =REL: SETF1-AL24 + differential value (differential = 0.3 bar or 1° C) IfAC2 =ABS: AL24 + differential value (differential = 0.3 bar or 1° C)
HAC1	maximum pressure (temperature) compressors alarm for circuit 1	IfAC1 = REL: suction pressure or temperature ≥ SETC1+AL4 IfAC1 = ABS: suction pressure or temperature ≥ AL4	BPV is closed if MT compressors are prevented from running	**Automatically** when the pressure or temperature ≤ IfAC1 =REL: SETC1+AL4 - differential value (differential = 0.3 bar or 1° C) IfAC1 =ABS: AL4 - differential value (differential = 0.3 bar or 1° C)
HAF1	maximum pressure (temperature) fans section alarm for circuit 1	IfAC2 = REL: condenser pressure or temperature ≥ SETF1+AL25 for AL26 delay IfAC2 = ABS: condenser pressure or temperature ≥ AL25 for AL26 delay	If AL27 = yes, the compressors circuit 1 switch off with a delay from 2 different steps AL28 with T-scroll the DVI valve are off In case of parallel compression enabled (at least one of parallel compressor is working): All the parallel compressors are forced to stop with safety delays respected. The compressors of circuit 2 if configured are also switched off every AL28 sec. The BGV follows the behavior depending on parallel compressors or T-scroll compressor while the fans are running at maximum (AOCxx = 100% or all the fan on). The HPV valve is opened at max speed.	**Automatically** when the pressure or temperature ≤ IfAC2 =REL: SETF1+AL25 - differential value (differential = 0.3 bar or 1° C) IfAC2 =ABS: AL25 - differential value. (differential = 0.3 bar or 1° C)

Code	Description	Cause	Action	Reset
LL1	liquid level alarm for circuit 1	proper digital Input enabled (the Input is configured as DICxx=109, liquid level circuit 1) after delay CDI1	Only signaling	**Automatically** as soon as the input is disabled
PrSH1	pre-alarm for superheat circuit 1	superheat 1 is ≤ ASH1 + ASH2 and ≥ ASH2	Only signaling	**Automatically** when superheat exceeds ASH1 + ASH2 + hysteresis
ALSH1	alarm for superheat circuit 1	superheat 1 is ≤ ASH2	Depends on ASH4	**Automatically** when superheat exceeds ASH5 + ASH2
LPC1	electronic pressure switch for low temperature / pressure of circuit 1	pressure / temperature < AL21	Disable the compressors	**Automatically** when the pressure/temperature exceeds AL21 + differential
PR1	suction probe circuit 1 failure alarm	suction probe failure or out of range (e.g., the probe is configured as AICxx=1, NTC probe regulation suction circuit 1)	The compressors are activated according to the AL14/AL15 parameters.	**Automatically** as soon as the probe restarts working
PR3	condensing probe circuit 1 failure alarm	condensing probe failure or out of range (e.g., the probe is configured as AICxx=3, NTC probe regulation condensing circuit 1)	The fans are activated according to the AL31 parameters	**Automatically** as soon as the probe restarts working
Floodback 1	floodback alarm circuit 1	ASH2 >superheat (suction pressure and suction temperature) for 90 minutes	Only a warning: buzzer ON and alarm relay (91-Alarm) ON	**Automatically** when superheat > ASH2
Booster Alarm	booster configuration alarm	no compressor of circuit 1 available	Only signaling	**Automatically** as soon as a compressor of circuit 1 is available
Circuit 1 Alarm	circuit 1 alarm	serious alarm in circuit 1	Relay set as 115 is activated	**Automatically** as soon as the serious alarm condition is no longer
LOIL1	low oil level alarm circuit 1	For solution 1–3, ifDIC(i) = 161-low oil level in oil separator circuit1 activation for delay OIL12 For solution 4–5, ifDIC(i) = 186-low oil level in oil receiver circuit 1 activation for delay OIL12	During OIL12, according to OIL14 value ≥ inverter to max speed (if present) Once alarm active, if OIL16=1, all the compressors	**Automatically** as soon as the input is disabled. All the compressors restart working according to regulation.
HOIL1	high oil level alarm circuit 1	DIC(i) = 162-Hi oil level in oil separator circuit1 active after OIL24 cycles. If OIL24=0 we don't manage any warning.	Only signaling	**Manually** when the input is disabled, turn off and on the instrument or reset the alarm manually from the Visotouch.

Low Temperature Stage (Circuit 2) Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
LP2	low-pressure switch alarm for circuit 2	low pressure switch input 2 (the Input is configured as DICxx=102 low pressure circuit 2)	All compressors of circuit 2 are turned off, fans unchanged	**Automatically** if the number of activations are less than AL16 in the AL17 time when the input is disabled **Manually** if AL16 activation happened in the AL17 time when the input is disabled: turn the instrument off and on or reset the alarm manually from the Visotouch *Compressors restart working according to the working algorithm*
HP2	high-pressure switch alarm for circuit 2	high pressure switch input 2 (the Input is configured as DICxx=100 high pressure circuit 2)	All compressors of circuit 2 are turned off, all fans of circuit 2 are turned on	**Automatically** if the number of activations are less than AL37 in AL38 time when the input is disabled. **Manually** if AL37 activation happened in the AL38 time when the input is disabled: turn the instrument off and on or reset the alarm manually from the Visotouch *Compressors and fans restart working according to the working algorithm*
LAC2	minimum pressure (temperature) compressors alarm for circuit 2	if AC1 = REL: suction pressure or temperature ≤ SETC2-AL6 IfAC1 = ABS Suction pressure or temperature ≤ AL6	Only signaling	**Automatically** as soon as the pressure or temperature reaches IfAC1 =REL: SETC2-AL6 + differential value (differential = 0.3 bar or 1° C) IfAC1 =ABS: AL6 + differential value (differential = 0.3 bar or 1° C)

Code	Description	Cause	Action	Reset
HAC2	maximum pressure (temperature) alarm compressors for circuit 2	IfAC1 = REL: suction pressure or temperature ≥ SETC2+AL7 IfAC1 = ABS: suction pressure or temperature ≥ AL7	Only signaling	**Automatically** when the pressure or temperature ≤ IfAC1 =REL: SETC2+AL7 - differential value (differential = 0.3 bar or 1° C) IfAC1 =ABS: AL7 - differential value (differential = 0.3 bar or 1° C)
PrSH2	pre-alarm for superheat circuit 2	superheat 2	Only signaling	**Automatically** when superheat exceeds ASH1 + ASH9 +hysteresis
ALSH2	alarm for superheat circuit 2	superheat 2 is ≤ ASH9	Depends on ASH11	**Automatically** when superheat exceeds ASH12 + ASH9
LPC2	electronic pressure switch for low temperature / pressure of circuit 2	pressure / temperature < AL23	Disables the compressors	**Automatically** when the pressure / temperature exceeds AL23+differential
PR2	suction probe circuit 2 failure alarm	suction probe failure or out of range (e.g., the probe is configured as AICxx=2, NTC probe regulation suction circuit 2)	The compressors are activated according to the AL18 parameters	**Automatically** as soon as the probe restarts working
PR4	condensing probe circuit 2 failure alarm	condensing probe failure or out of range (e.g. the probe is configured as AICxx=4, NTC probe regulation condensing Circuit 2)	The fans are activated according to the AL39 parameters.	**Automatically** as soon as the probe restarts working
Floodback 2	floodback alarm circuit 2	ASH9 > superheat (suction pressure & suction temperature) for 90 minutes	Only a warning: buzzer ON and alarm relay (91-Alarm) ON	**Automatically** when superheat > ASH9
Circuit 2 Alarm	circuit 2 alarm	there is a serious alarm in circuit 2	Relay set as 116 is activated	**Automatically** as soon as the serious alarm condition is no longer present

Compressor Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
EAO1–EAO24 (for each compressor)	compressor alarm oil safety switch	oil switch digital input activation (the Input is configured as DICxx=1, compressor oil pressostat compressor 1 circuit 1) NOTE: with step compressors input for each compressor has to be used	The corresponding compressor is turned off (with step compressors all relays referred to the input are disabled). With T-scroll the DVI valve are off and fans follow SL25.	**Automatically** as soon as the input is disabled
ETO1–ETO24 (for each compressor)	compressor alarm thermal safety	oil switch digital input activation (the input is configured as DICxx=3, thermal safety compressor circuit 1) NOTE: with step compressors input for each compressor has to be used	The corresponding compressor is turned off (with step compressors all relays referred to the input are disabled). With T-scroll the DVI valve are off and fans follow SL25.	**Automatically** as soon as the input is disabled
EPO1–EPO24 (for each compressor)	compressor alarm pressure safety	pressure switch digital input activation (the input is configured as DICxx=2, thermal safety compressor circuit 1) NOTE: with step compressors input for each compressor has to be used	The corresponding compressor is turned off (with step compressors all relays referred to the input are disabled). With T-scroll the DVI valve are off and fans follow SL25.	**Automatically** as soon as the input is disabled
MANT	compressor maintenance alarm	a compressor has worked for the time set in the AL10 parameter	Only signaling	**Manually** reset the running hour of the compressor
Compressor Start (1–15)	compressor cycle limit	compressor CT cycle counter > SL14 CT cycle counter will come from Coresense by reading register address “007E” (compressor start times) when this value > SL14 individual compressor is locked out until cycle count is reset	Lockout individual compressor	no reset

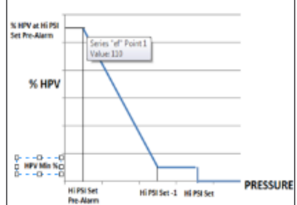
Code	Description	Cause	Action	Reset
OIL DIFF L/O	high separator differential switch alarm	contact closure from high oil separator lockout input	Lockout all compressors when DI true > 5 min	**Automatically** when DI true < 5 min **Manually** when DI true ≥ 5 min When the input is disabled, it also needs turn the instrument off and on or reset the alarm manually from the Visotouch or remote As soon as the input is disabled the alarm is reset, the compressors restart working according to the working algorithm.

Generic Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
P1 to P25	probe failure alarm	probe 1 to 25 failure	Only signaling	**Automatically** as soon as the probe restarts working
BURST	burst disc alarm	DIC(i) = 150 activation	Only a warning: buzzer ON and alarm relay (91-Alarm) ON	DIC(i) = 150 deactivation
PHASE	phase fail alarm	DIC(i) = 151 activation	Only a warning: buzzer ON and alarm relay (91-Alarm) ON	DIC(i) = 151 deactivation
EXT[i]	external alarm	DIC(i) = 152 [152–155] activation	Only a warning: buzzer ON and alarm relay (91-Alarm) ON	DIC(i) = 152 [152–155] deactivations
GLeak1[1–4]-PreAlr	gas leak pre-alarm 1 [1–4]	if value of gas leak detector 1 [1–4] probe > GLD1 [GLD6-GLD11-GLD16] and gas leak detector 1 [1–4] probe < GLD2 [GLD7-GLD12-GLD17].	Relay set in GLD4 [GLD9-GLD14-GLD19] on	When value of Gas leak detector 1 [1–4] probe ≤ GLD1- GLD3 [GLD6-GLD8;GLD11-GLD13;GLD16-GLD18]
GLeak1[1–4]-Alarm	gas leak alarm 1 [1–4]	if value of gas leak detector 1 [1–4] probe > GLD2 [GLD7-GLD12-GLD17]	Relay set in GLD5 [GLD10-GLD15-GLD20] on	When value of Gas leak detector 1 [1–4] probe ≤ GLD2- GLD21 [GLD7-GLD22;GLD12-GLD23;GLD17-GLD24]
EMOA-106D	expansion module offline alarm IPX106D	the expansion module IPX106D is used and loses communication by can bus	Only signaling	**Automatically**
EMOA-215D	expansion module offline alarm IPX215D	the expansion module IPX215D is used and loses communication by can bus	Only signaling	**Automatically**.

Compressors with Inverter Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
INVO (for suction inverter)	inverter safeties alarm for oil switch	oil switch digital input activation (the input is configured as DICxx=115, compressor oil Inverter suction circuit 1)	The corresponding inverter is turned off	**Automatically** as soon as the input is disabled.
INVT (for suction inverter)	inverter safeties alarm for thermal switch	thermal switch digital input activation (the input is configured as DICxx=117, thermal safety inverter suction circuit 1)	The corresponding inverter is turned off	**Automatically** as soon as the input is disabled.
INVP (for suction inverter)	inverter safeties alarm for pressure switch	pressure switch digital input activation (the input is configured as DICxx=116, safety inverter suction circuit 1)	The corresponding inverter is turned off	**Automatically** as soon as the input is disabled.
MANTINV1 (for suction inverter)	inverter 1 maintenance alarm	inverter 1 has worked for the time set in the AL10 parameter	Only signaling	**Manually** reset the running hour of the inverter1 [2]

Fan Control Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
AL–AO (for each fan)	fan safeties alarm	safety switch digital input activation (the input is configured as DICxx=73, fan 1 safety circuit 1)	The corresponding fan is turned off	**Automatically** as soon as the input is disabled

Warning Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
OIL DIFF HI	change separator element switch alarm	contact closure from change oil separator input >1 minute	Only a warning: buzzer ON and alarm relay ON	**Automatically** when DI is false
Floodback	floodback alarm	10 DDF > superheat (suction pressure and suction temperature) for 90 minutes	Only a warning: buzzer ON and alarm relay ON	**Automatically** when superheat > 10 DDF

Gas Cooler Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
PreHP REC	high pressure on CO_2 flash tank pre-alarm	GC28 > AI152 (AI153) > GC29	The % of the valve updates every second in order to reach the correct percentage If the flash tank pressure value is between the values GC29 and GC28 - 1 bar, the % of valve opening is the following one:  	**Automatically** as soon as the HP REC is active or as soon as AI152 (AI153) < GC29 – GC30
HP REC	high pressure on CO_2 flash tank alarm	AI152 (AI153) > GC28	The HPV will close (0%) BYPASS will open to a user definable % set by the BYPASS % open parameter GC37 BYPASS valve is opened at GC26	**Automatically** as soon as AI152 (AI153) < GC28 – GC30
LP REC	low pressure on CO_2 flash tank alarm	AI152 (AI153) < GC31	The HPV will have a minimum opening of the HPV valve to a user definable % set by GC36 If the PID % is greater than GC36, then the PID % will be the valve % output the BYPASS will close	**Automatically** as soon as AI152 (AI153) > GC31 + GC32
OA-XEV20D_1	XEV20D_1 offline alarm	The XEV20D_1 is used and loses communication	Only signaling	**Automatically**
OA-XEV20D_2	XEV20D_2 offline alarm	The XEV20D_2 is used and loses communication	Only signaling	**Automatically**
HDi-T-1	high discharge temperature – circuit 1	one of the probes set as AIxxx = 156, 158, 169–180 >DSC4 and DSC5 timer exhausted	With DSC6 running only warning With DSC6 exhausted 1 compressor off every DSC7 sec	**Automatically** as soon as ALL the probes set as AIxxx = 156, 158, 169–180, Aixx < DSC4 – DSC3
HDi-T-2	high discharge temperature – circuit 2	one of the probes set as AIxxx = 157, 159, 181–192 >DSC11 and DSC12 timer exhausted	With DSC13 running only warning With DSC13 exhausted 1 compressor off every DSC14 sec	**Automatically** as soon as AIxxx = 157, 159, 181–192 < DSC11 – DSC10

Code	Description	Cause	Action	Reset
HDLT-1	high discharge temperature – DVi circuit 1	DLT temperature too high	Compressor off every second, EHXV = 0%, fans follow SL25	**Automatically** as soon as all the probes detect a safety DLT temperature
H_EHXP	high EHXP	DVI pressure too high and DLT too high	Compressor off every second with T-scroll, EHXV = 0%, fans follow SL25	**Automatically** as soon as EHXP reverts to safety values
LSH_EHX	low SH in heat exchanger	SH ≤ SHX12 for SHX14	EHXV % will be forced to 0%	**Automatically** as soon as the SH ≥ SHX12+1DC
HSH_EHX	high SH in heat exchanger	SH ≥ SHX13 for SHX15	EHXV % will be forced to max% (i.e., SHX11)	**Automatically** as soon as the SH ≤ SHX13-1DC
MOP_EHX	maximum operating pressure in heat exchanger	EXP ≥ SHX17 for SHX19	If the EXP > SHX17, the EHXV output steps will decrease the steps specified by parameter SHX20 every one second until the valve % reaches the min % (SHX10) If the EXP < SHX17 - 1DC, the EHXV output steps will increase the steps specified by parameter SHX20 every one second until the valve % reaches the max % (SHX11)	**Automatically** as soon as the SH is not above the SH setpoint
SHX16_EHX	minimum operating pressure in heat exchanger	EXP ≤ SHX16 for SHX18	EHXV output steps will increase the steps specified by parameter SHX20 every one second until the valve % reaches the max % (SHX11)	**Automatically** as soon as the SH is not above the threshold of low superheating (SHX12) or the EXP is above the SHX16+4DC

Code	Description	Cause	Action	Reset
Inv1_Trip	inverter trip alarm for circuit 1	inverter trip - circuit 1 digital input (the input is configured as DICxx=140)	Inverter compressor of circuit 1 is turned off, with T-scroll the DVI valve is off	**Automatically** if the number of activations are less than AL41 in the AL42 time, after DOCxx = 118 activation **Manually** (if AL41 activation happened in the AL42 time) When the input is disabled, turn the instrument off and on / or reset the alarm manually from the Visotouch The compressors restart working according to the working algorithm
Inv2_Trip	inverter trip alarm for circuit 2	inverter trip - circuit 2 digital input (the input is configured as DICxx=141)	Inverter compressor of circuit 2 is turned off, with T-scroll the DVI valve is off	**Automatically** if the number of activations are less than AL44 in the AL45 time, after DOCxx = 119 activation **Manually** (if AL44 activation happened in the AL45 time), when the input is disabled: turn the instrument off and on or reset the alarm manually from the Visotouch The compressors restart working according to the working algorithm

Envelope Control Alarms				
Code	**Description**	**Cause**	**Action**	**Reset**
LEVA1 [2] (for suction inverter)	low evap region alarm 1 [2]	inverter has worked in low evap region after delay ENV1 for circuit1, ENV6 for circuit 2 is elapsed	Only signaling	**Automatically** as soon as the evaporation temp/ pressure is out of the low evaporation region **Manually,** the alarm can be reset when inverter is off
Out of Range 1 [2] (for suction inverter)	inverter compressor speed is out of range of min/max speed 1 [2]	AI152 (AI153) > GC28	Only signaling	**Automatically** as soon as min compressor speed ≤ the inverter compressor speed ≤ max compressor speed **Manually,** the alarm can be reset when inverter is off
MIN_ EVAP1[2] (for suction inverter)	min evap alarm 1[2]	inverter has worked with evaporation temp/press < absolute min evaporation temperature/pressure	After delay ENV2 for circuit1 (ENV7 for circuit 2) is elapsed, shutdown all the compressors of the circuit. Fans follow SL25.	**Automatically** as soon as evaporation temperature ≥ Absolute Min evaporation temperature/pressure **Manually,** the alarm can be reset when inverter is off
MAX_ EVAP1[2] (for suction inverter)	max evap alarm 1[2]	inverter has worked with evaporation temp/press > absolute max evaporation temperature/pressure	After delay ENV3 for circuit1 (ENV8 for circuit 2) is elapsed, shutdown all the compressors of the circuit. Fans follow SL25.	**Automatically** as soon as evaporation temperature ≤ absolute max evaporation temperature/pressure **Manually,** the alarm can be reset when inverter is off
MIN_COND1[2] (for suction inverter)	min cond alarm 1[2]	inverter has worked with condensing temp/press < absolute min cond temperature/pressure	After delay ENV4 for circuit 1 (ENV9 for circuit 2) is elapsed, shutdown all the compressors of the circuit. Fans in circuit1 are stopped if MIN_COND1 occurs. If fans in circuit2 are configured, stopped them when MIN_COND2 occurs.	**Automatically** as soon as condensing temperature ≥ absolute min cond temperature/ pressure **Manually,** the alarm can be reset when inverter is off

Code	Description	Cause	Action	Reset
MAX_ COND1[2] (for suction inverter)	max cond alarm 1[2]	inverter has worked with condensing temp/press > absolute max cond temperature/pressure	After delay ENV5 for circuit1 (ENV10 for circuit 2) is elapsed, shutdown all the compressors of the circuit. Fans follow SL25.are forced on Fans in circuit1 are forced on if MAX_ COND1 occurs. If fans in circuit2 are configured, force on them when MAX_COND2 occurs.	**Automatically** as soon as condensing temperature ≤ absolute max cond temperature/ pressure **Manually,** the alarm can be reset when inverter is off
EMG_ENV [2] (for suction inverter)	emergency envelope alarm 1[2]	emergency envelope status is TRUE	After delay ENV13 for circuit1 (ENV14 for circuit 2) is elapsed, shutdown all the compressors of the circuit. Fans follow SL25.	**Automatically** as soon as emergency envelope status is FALSE **Manually,** the alarm can be reset when inverter is off

Communication

All Protocol and gas cooler I/O boards are located at the main protocol control panel on the protocol frame. The boards are networked to the main Protocol controller via the local board network. The main Protocol controller will also communicate with the high-pressure controller and EEV case controllers.

Protocol controllers (XC Pro) use CAN BUS connections for expansions boards (IPEXx0D) and drivers for electronic valves (XEVx0D) and connections RS485 (master/slave) to connect a supervisory system like an E3.

Protocol controller (XC Pro) can also be connected to a PC via a direct ethernet connection to manage its settings.

Compressor Staging

Typical suction groups for CO_2 are Low Temperature (e.g., -20° F [-28.9° C]) and Medium Temperature (e.g., 20° F [-6.7° C]). The staging typically maintains the suction manifold pressure +/- 2F SST of the target setpoint.

It is common for CO_2 Systems to include a feature to allow the lead compressor to operate below target setpoint, pulling the suction pressure down to the pump down setpoint. Pump down allows a larger operating range typically when under low loads and reduces lead compressor cycles. As the suction pressure rises above the setpoint range, the controller will add compressor capacity by increasing the voltage to the VFD or Digital Unloaders and by staging ON compressors; conversely as the suction pressure decreases below the setpoint range compressors will be staged OFF and the VFD or Digital Unloaders will decrease capacity.

Parameter	Value	Unit	Remarks
LT suction pressure pumpdown	162	psig	typical setpoint
LT suction pressure	162–208	psig	typical operating range
MT suction pressure pumpdown	328	psig	typical setpoint
MT suction pressure	328–420	psig	typical operating range

Compressor Capacity Control

All compressor capacity control sequences will be executed by the Protocol controller. The control circuit for each compressor is routed through a relay output point controlled by the Protocol controller. The control circuit provides control power to each compressor contactor's coil. The compressor relay outputs are normally open, which prevents the compressors from running unless the EMS has full control of the system.

Each compressor will incorporate a mechanical high pressure safety switch that will break voltage to the compressor contactor in the event of a high-pressure trip. Steps should be taken to prevent frequent compressor cycles in case of multiple, subsequent high-pressure events. Automatic or manual reset. The discharge pressure will be monitored by the refrigeration controller (XC Pro monitors the discharge pressure value through the obtained discharge temperature value). In the event of a high discharge pressure event, the refrigeration controller stops the compressors until the high discharge pressure (temperature) condition has cleared. However, during a high suction event (e.g., MOP) a command to turn off all circuits is sent while allowing the Protocol to stage as normal.

Each suction group will be provided with at least one variable capacity compressor. The Protocol controller will provide a signal through an analog output to the medium temperature compressor's VFD or low temperature digital unloader (e.g., CM-RC). The Protocol controller will determine the voltage output required to provide the percentage of required unloading to maintain the suction pressure setpoint. All compressor staging is designed to maintain the suction pressure setpoint with overlap in capacity to reduce short cycle and staging up or down.

Parameter	Value	Unit	Remarks
MT low suction pressure	345	psig	suction group failure and alarm
LT low suction pressure	160	psig	suction group failure and alarm
MT high suction pressure	520	psig	suction group alarm only
LT high suction pressure	290	psig	suction group alarm only
MT high discharge setpoint	1,522	psig	suction group failure and alarm
LT high discharge setpoint	510	psig	suction group failure and alarm
MT discharge pressure	600–1,300	psig	typical operating range
LT compressor VFD Hz range	30–75	Hz	typical compressor speed range
MT compressor VFD Hz range	25–70	Hz	typical compressor speed range
compressor minimum off-time	3	min	typical setting
compressor hourly running cycles exceeded alarm	10	starts/hr	typical setting (starts per hour)

Oil Management

The Protocol CO_2 has two distinct oil management areas, only one of which is controlled by the Protocol controller. The EMS will control the level and draining of the oil separator, only located on the discharge of the MT compressors. Any time the oil separator indicates the oil level is high, the Protocol controller will pulse the oil drain solenoid. This is to ensure ample time is given to drain the separator but not excessively so to send hot gas to the flash tank. The oil drain solenoid may also pulse open in the event of a trouble compressor, unable to fill with oil (when applicable).

Ensure that during high ambient conditions the duty cycle of the oil drain solenoid is enough to drain the separator. For example, a cycle of 15 seconds open with 45 seconds closed may be sufficient.

The compressors are equipped with Emerson OMC CO_2 oil level controls. The OMC monitors the compressor oil level and will open the compressor oil solenoid to fill the compressor when the oil level drops. The OMC is connected to the compressor control circuit and will interrupt control power when unable to fill to required level due to low oil supply. The OMC sends a digital closure to indicate oil alarm condition. The protocol controller will generate an oil fail alarm.

Parameter	Value	Unit	Remarks
oil separator drain pulse time	15	sec	
oil separator drain period time	45	sec	
typical oil pressure	490–550	psig	pressurized with flash tank, maintain > 75 psig MT SP
typical oil drain cycles	20–40	per/hr	

Heat Reclaim Control

When applicable, CO_2 heat reclaim can be incorporated with either air (e.g., space heating or dehumidification) or water (e.g., domestic hot water).

Air Heat Reclaim

One mounted plate heat exchanger using CO_2 to heat glycol/water mixture which is pumped to an HVAC unit. Installed 3-way modulating valve and one fluid pump enabled by leaving fluid temperature to HVAC unit [on 130° F [54° C], off 200° F [93° C]). The modulating valve is controlled based on CO_2 pressure difference.

Also includes:

- Circuit setter valve on outlet of heat exchanger fluid line
- Strainer installed before pump
- Expansion tank on fluid return line
- Air scoop and purge valve on fluid return line
- Auto-fill tank on return fluid line
- Pressure relief valve on fluid supply line
- Heat reclaim coil needs to be rated for high pressure

Water Heat Reclaim

For water heat reclaim, a plate heat exchanger is typically utilized to heat domestic water

Gas Cooler Fan Control

The Protocol controller monitors the ambient, pad (when applicable) and gas cooler outlet temperature. The Protocol controller will calculate the temperature difference between the ambient (or pad if adiabatic) temperature and the gas cooler outlet temperature. The gas cooler fan speed will increase to bring down the gas cooler outlet temperature and vice versa to maintain the design delta temperature [typically 10° F [-12.2° C]). The gas cooler outlet temperature is usually limited to around 45°–50° F (7.2°–10° C) help maintain to a minimum discharge pressure. Also, the gas cooler outlet temperature is typically capped to around 80° F (26.7° C) to try to limit the amount of time in transcritical. There may also be a setpoint (ambient or gas cooler outlet or pressure) to force the gas cooler fans on to 100 percent.

Most gas coolers are designed with fans that utilize VFDs or EC motors to allow for variable speed regulation. It is recommended to incorporate a 10–0 V (rather than 0–10 V) analog control signal to modulate the gas cooler fans. That way, if the control signal is lost, the gas cooler fans will be failsafe to 100% of their rated speed.

Some gas cooler manufacturers will provide a digital signal in the event of a general gas cooler fan alarm. This alarm should be communicated through the refrigeration controller to notify the refrigeration service provider. If the gas cooler alarm is the result of an EC gas cooler fan failure, the refrigeration controller typically commands the remaining operable gas cooler fans to run at 100 percent of their nominal speed.

Parameter	Value	Unit	Remarks
gas cooler outlet TD setpoint	3–9	° F	typical setting
gas cooler outlet temperature	41–100	° F	typical operating range

High Pressure Valve (HPV)

The HPV is controlled by the main Protocol controller. The controller will monitor the gas cooler outlet temperature and gas cooler outlet pressure. The HPV will switch control modes depending on the temperature or pressure leaving the gas cooler. The following modes of operation are ordered from high ambient to low ambient.

- High Discharge—If the pressure is at or above its maximum pressure setpoint, the HPV will abandon its COP algorithm and maintain a high pressure setpoint (e.g., 1,522 psig).
- Supercritical—If the pressure and temperature indicate the system is in transcritical, the HPV will maintain a pressure setpoint for optimal performance. This COP curve varies per manufacturer.
- Transition—If the pressure and temperature indicate the system is near the transcritical and subcritical region of CO_2, the controller will smoothly transition from one mode to the other.
- Subcritical—If the pressure and temperature indicate the system is subcritical, the HPV will maintain a sub-cooled liquid in the gas cooler. The HPV will typically maintain a value between 3° F and 9° F (-16.1° C and -12.8° C).
- Holdback—If the pressure is below the minimum pressure setpoint, the HPV will abandon the subcritical algorithm and maintain the pressure setpoint (e.g., 652 psig [45 bar]).

The HPV may also have features to protect the Protocol from a pressure relief event.

- High Flash Tank Pressure—If the flash tank pressure is above the high-pressure limit, the HPV will start to close to give the flash tank pressure a chance to decrease. If the flash tank pressure is excessive, the HPV may close completely to prevent a pressure relief.
- Low Flash Tank Pressure—If the flash tank pressure is below the low-pressure limit, the HPV will start to open to give the flash tank pressure a chance to increase. If the flash tank pressure is dangerously low, the HPV may open completely to try to pressurize the flash tank.
- If the gas cooler outlet pressure is lost, failsafe to the remote discharge pressure.
- If the gas cooler outlet temperature is lost, failsafe the valve position to current position or the average position.
- If in the event either pressure transducer or temperature sensor is lost and the average HPV position is not known, set valve OD% to 50%.

Flash Tank

Most flash tanks are equipped with monitoring to determine how much liquid is in the tank (e.g., analog level) or if the tank is low on liquid (e.g., low level switch). The low liquid level indication is accomplished using an optical sensor that is calibrated to sense liquid CO_2. This sensor provides an electrical signal (e.g., digital input) to the Protocol controller. The low-level switch is installed near the bottom of the flash tank (e.g., 20%) but above the dip tube where liquid is drawn from the tank. An alarm should trigger if the switch indicates low liquid.

Flash Gas Bypass Valve (FGB)

The FGB Valve has a static flash tank pressure setpoint. The valve will open to relieve pressure from the flash tank. It is common for this valve to be closed under low load and low ambient conditions, opening periodically to relieve any pressure once above the flash tank pressure setpoint. It's recommended that the flash tank pressure maintains at least 75psig above the MT Suction Pressure to ensure proper oil pressure.

Parameter	Value	Unit	Remarks
flash tank pressure setpoint	500–575	psig	typical flash tank setpoint
flash tank pressure	480–565	psig	typical operating range

Liquid Injection

The liquid injection valve connects the liquid line to the MT suction header. The expansion valve will energize to help maintain the MT suction superheat or discharge temperature. A pulse width modulation expansion valve (e.g., Danfoss AKV or Sporlan SPW) is used to meter liquid refrigerant into the MT suction line. Control of this valve is based on the calculated MT suction superheat.

Ensure that during high superheat conditions the duty cycle (and valve selection) is appropriate to lower the suction superheat at full load. For example, a cycle of 15 seconds open with 45 seconds closed may be sufficient.

Parameter	Value	Unit	Remarks
MT LI superheat setpoint	54	° F	typical superheat setpoint
MT discharge temp setpoint	250	° F	typical discharge setpoint
MT suction superheat	20–40	° F	typical operating range
MT discharge temperature	150–250	° F	typical operating range

Hot Gas Injection (superheat)

The hot gas dump connects the MT discharge to the MT suction header. The expansion valve will energize to help maintain the MT suction superheat. A pulse width modulation expansion valve (e.g., Danfoss AKV or Sporlan SPW) is used to meter hot gas into the MT suction line. Control of this valve is based on the calculated MT suction superheat.

Ensure that during low superheat conditions the duty cycle (and valve selection) is appropriate to increase the suction superheat at full load. For example, a cycle of 15 seconds open with 45 seconds closed may be sufficient.

Parameter	Value	Unit	Remarks
MTHG superheat setpoint	20	° F	typical superheat setpoint
MT suction superheat	20–40	° F	typical operating range
superheat alarm setpoint	10	° F	suction group alarm only

Phase Loss (main feed)

The PLM provides a digital input to the protocol controller anytime the voltage is outside the nominal range of the system. When a PLM provides a contact closure, the Protocol goes into an emergency event. It is recommended that the digital input closure be provided with a 1–3 second programmed delay to prevent any false trips due to transient voltage on the cable or input board. A longer delay may be required to prevent an intermittent shutdown when the Protocol switches to generator power. It is recommended that the PLM module does not include any significant delays. The Protocol controller should incorporate those delays as part of its stage up sequence.

An emergency event can be triggered by multiple scenarios but all result in the same action. For example, a phase loss, high discharge pressure or all MT compressors locked out for any reason results in an emergency event. During an emergency event all compressors will be kept off until the event clears, until which the system is allowed to go through the circuit stage-up scenario. During this period, it is typical to have the HPV and FGB remain closed, defrosts disabled, evaporator fans off, and EEVs closed. This is to limit heat exposure (excess pressure) to the system and prolong the containment of CO_2 inside the Protocol until the event clears.

Circuit Stage-Up (after shutdown)

Anytime the Protocol exhibits an emergency event, the system will go through a staged approach to systematically turn the system back on. After the emergency event clears and a short delay (typically 60 seconds), the compressors are allowed to stage back up. At the same time, if suction pressures are within nominal range the evaporator loads get enabled again. The number of circuits that turn back on at a time can vary and is usually setup on a per store basis, which typically consists of about 15–25% of the total system. The order of circuits can also vary on a per-store basis but typically consists of critical product first (e.g., meat, service, etc.) and less critical circuits last (e.g., produce, beverage, prep rooms, etc.).

Protocol Controller Operation

XC Pro Functions Control

All parameterization on the XC Pro is done through the WIZMATE application downloaded onto a PC/laptop connected via an ethernet cable or RS-485 connection directly to the controller.

Booster

Booster function forces the activation of a compressor in medium temperature line when a compressor in low temperature line is active. This is suggested in small racks with reduced number of compressors. The gas coming from the low temperature line is compressed by the compressors in medium temperature line (low temperature line is without condensation).

Booster functionality can be enabled by safety compressor parameter SL11. This function is enabled when the capacity for the single compressor in low temperature line is very close to the capacity of the single compressor in medium temperature line.

The function is active for safety compressor parameter SL14 timing (seconds), expiring when the compressors in circuit 1 are no longer be forced ON, but they will follow the standard regulation (independent circuits). During SL14 timing, any alarms that stop all the compressors in circuit 1 (MT) will also stop the compressors in circuit 2 (LT) generating booster alarm and circuit alarm.

The activation of a compressor circuit 1 (MT) is delayed by a few seconds after the activation of the compressor circuit 2 (LT) to avoid current peaks and for circuit 1 preload.

Subcritical and Transcritical Mode

The temperature value read from T OUT_GC (gas cooler outlet temperature) probe placed on the outlet of the gas cooler defines if XC Pro works in subcritical mode or in transcritical mode.

<u>Gas Cooler - Condenser, Subcritical Mode</u>

For temperatures typically below the CO_2 critical point (87.8° F [31° C] and a pressure of 1,071 psig [73.8 bar]) the system works in subcritical mode.

The CO_2 refrigerant condenses inside the gas cooler (condenser). The temperature read by the gas cooler outlet temperature probe defines the speed of the fan in the gas cooler. The HP valve works to maintain the proper pressure inside the gas cooler to ensure a natural subcooling and a correct compression ratio—high COP (Coefficient of Performance).

<u>Gas Cooler - Condenser, Transcritical Mode</u>

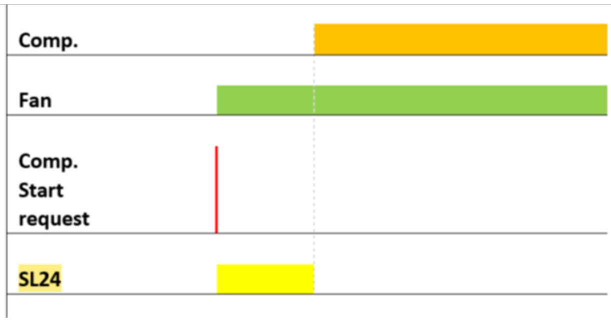
For temperatures typically over the CO_2 critical point the system operates in transcritical mode.

According to gas cooler outlet temperature (T OUT_GC) the HP valve modulates to maintain a pressure that maximizes the COP.

Compressor and Fan Start Synchronization

This function allows to prepare the gas cooler when the compressor must start to avoid pressure jumping when the gas cooler is without ventilation.

It is possible to enable the function by safety compressor parameter SL24 if the thermoregulation requires compressors activation the fans will be immediately enabled, and the compressors will be enabled after gas cooler parameter GC 110 (seconds) delay.



Gas Cooler Safety Operation

<u>Standard HPV Operating Mode</u>

The HPV works to maintain the optimal pressure calculated according to the gas cooler outlet temperature. The maximum setpoint used is the value set by gas cooler parameter GC13 (maximum allowable pressure setpoint for gas cooler). This value can be reduced if the envelope protection is activated, according to the real working conditions.

<u>High Pressure (HP) Alarm and Compressor Cut Out</u>

If the gas cooler pressure is over the gas cooler parameter GC19 (gas cooler pressure threshold to stop compressors in case of high pressure in the gas cooler) the XC Pro begins stopping the compressors to avoid the pressure still increases. The fans work at maximum speed. The HP valve will be open to try decreasing the pressure in the gas cooler.

The alarm recovers when the pressure goes below GC19 — 72.5 psig (5 bar).

<u>High Pressure (HP) Alarm and Mechanical Pressure Switch Activation</u>

If the gas cooler pressure will be over than the gas cooler parameter GC14 (pressure threshold to restart opening HPV valve after a HP digital input trigger) and we have also the activation of the high-pressure switch the HP valve will be closed for protecting the liquid receiver.

After a HP digital input trigger, the HPV valve doesn't open till the pressure goes below this GC14 value.

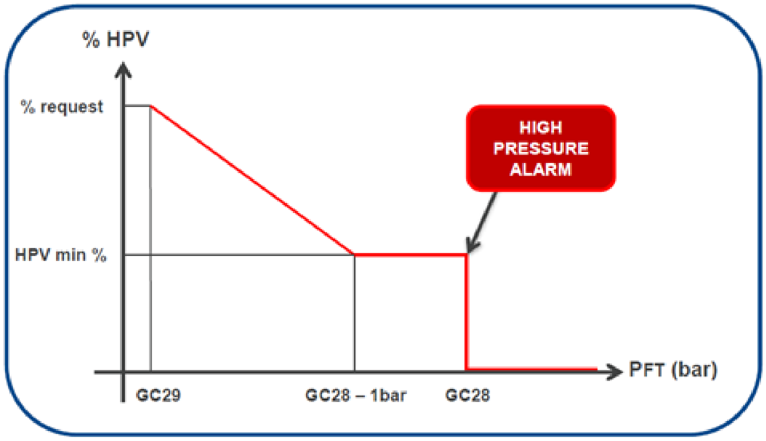
Flash Tank Safety Operation

<u>Bypass Valve (BPV)</u>

BPV It is used to maintain the optimal pressure inside the flash tank. BPV injects gas to medium temperature suction line (bypass line), according to the pressure detected by flash tank pressure probe (P FT).

<u>Safeties for High Pressure in Flash Tank</u>

To avoid high pressure alarm conditions in flash tank, there is a pre alarm area where HP valve is closed in a proportional way to the receiver pressure. If the flash tank pressure (P FT) > GC 29 (flash tank high pressure setpoint pre-alarm) then % HP valve will be updated according to the chart below.



The gas cooler fans will be forced to maximum speed to try to decrease the flash gas quantity.

If the pressure increases over GC 28 (high pressure setpoint alarm) the following actions take place:

- HPV will be closed
- BPV will be opened to gas cooler parameter value GC 37 (BPV % open during high pressure safety mode)
- High pressure alarm notification on the Visotouch

<u>Safeties for Low Pressure in Flash Tank</u>

If Flash Tank pressure (P FT) < GC 31 (low pressure setpoint alarm) the following actions take place:

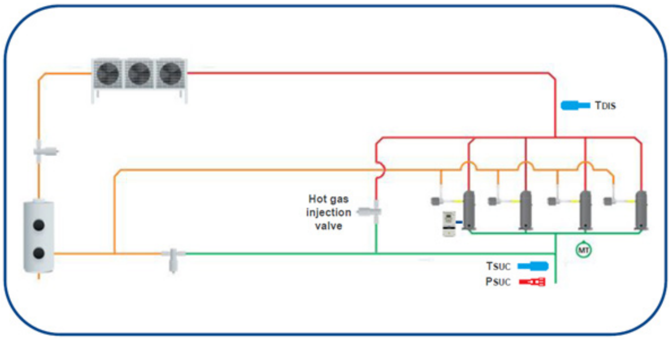
- BPV will be closed
- HPV will be opened to gas cooler parameter value GC 36 (HPV % open during low pressure safety mode)
- Low pressure in flash tank alarm active
- It is possible enable the hot gas injection valve and open it to inject hot gas from discharge compressor line directly into flash tank

Hot Gas Injection Valve Management

The action is to inject hot gas into circuit 1 (MT) suction line.

Resources used:

- P SUC—suction pressure circuit 1 (value in temperature)
- T SUC—auxiliary suction temperature probe circuit 1
- DOC XX = 105—digital output for hot gas injection valve circuit 1



<u>The purpose of hot gas injection is to:</u>

Increase superheat temperature value (circuit 1): at least 1 compressor active in circuit 1. SH1 (Superheat Circuit 1) calculation starts 1 minute after the activation of the first compressor in circuit 1. If there's a probe error, the hot gas valve is not active.

The relay configured DOC XX = 105 as hot gas injection valve circuit 1 works as a thermostat with inverse action (hot), using the superheat value as the control variable.

SH1 = T SUC ("NTC AUX temperature probe suction circ.1") – P SUC ("probe suction circuit 1")

ASH8 = superheat value 1 at which to enable valve 1 for injecting hot gas (hot action)

ASH9 = differential for ASH8

if SH1 ≤ ASH8 – ASH9 → relay configured as DOC XX = 105 is on

if SH1≥ ASH8 → relay configured as DOC XX = 105 is off

if ASH8 – ASH9 < SH1 < ASH8 → maintains the previous status (it the relay was on, it stays in on; if it was in off, it stays in off)

Increase suction temperature value (circuit 1): superheat parameter ASH20 =YES (hot gas valve circuit 1 activation for temperature control). At least 1 compressor active in circuit 1. Temperature control starts 1 minute after the activation of the first compressor in circuit 1. If there's a probe error, the hot gas valve is not active.

At least one temperature probe, among the following, is set as auxiliary probe, mounted on the suction line:

AI XX = 17 "NTC AUX temperature probe suction circ.1"

AI XX = 45 "NTC suction temperature compressor 1 circuit 1"

AI XX = 56 "NTC suction temperature compressor 12 circuit 1"

The relay configured DOC XX = 105 as hot gas injection valve circuit 1 works as a thermostat with inverse action (hot), using the temperature values coming from the probe sets as AI XX = 17, 45, …, 56, respecting the following conditions:

If at least one of the probes ≤ ASH21 – ASH22 → hot gas valve is on

If all the probes ≥ ASH21 → hot gas valve is off

Else → maintains the status

ASH21 = suction 1 temperature value at which the hot gas valve is enabled (hot action)

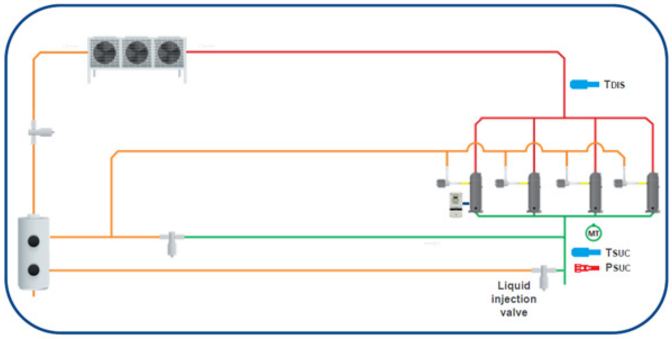
ASH22 = differential for ASH21

Liquid Injection Valve Management

This action is to inject liquid into circuit 1 (MT) suction line.

Resources used:

- P SUC - suction pressure circuit 1 (value in temperature)
- T SUC - auxiliary suction temperature probe circuit 1
- DOC XX = 123 - digital output for liquid injection valve circuit 1
- T DIS - discharge temperature
- AO X: analog output with PWM signal (ON/OFF time can be set by parameter)



The purpose of liquid injection is to:

Decrease superheat temperature value (SH1): superheat parameter ASH26 =YES (liquid injection valve circuit 1 activated also by SH control). The SH1 control starts 1 minute after the start of the first compressor of the circuit 1.

The relay configured DOC XX =123 works as a thermostat, with cooling action, using the superheat value as the control variable.

SH1 = T SUC ("NTC AUX temperature probe suction circ.1") – P SUC ("probe suction circuit1")

ASH27 = high superheat value of circuit 1 to enable liquid injection (cooling action)

ASH28 = differential for ASH27

if SH1≥ ASH27 + ASH28 → relay configured as DOC XX = 123 is on

if SH1 ≤ ASH27 → relay configured as DOC XX = 123 is off

if ASH27 < SH1 < ASH27+ASH28 → maintains the previous status

Decrease suction temperature value (circuit 1): The temperature control parameter is enabled, ASH32 =YES (liquid injection valve, circuit 1, activated also by temperature control). The 2 below conditions must be satisfied before starting the temperature check and control:

The temperature of the circuit 1 (MT) is monitored ONLY if at least one compressor of the circuit 1 is running

The temperature control starts after ASH33 (delay after compressor start, before initiating the suction temperature control) minutes after the start of the first compressor of the circuit 1

At least one temperature probe, among the following, is set as auxiliary probe, mounted on the suction line:

AI XX = 17 "NTC AUX temperature probe suction circ.1"

AI XX = 45 "NTC suction temperature compressor 1 circuit 1"

AI XX = 56 "NTC Suction Temperature Compressor 12 Circuit 1"

The relay configured as DOC XX = 123 "Liquid injection valve circuit 1" works as a thermostat with direct action (cooling), using the temperature values coming from the probe sets as AI XX = 17, 45, …, 56, respecting the following conditions:

If at least one of the probes ≥ ASH34 + ASH35 → relay configured as DOC 123 is on

If all the probes ≤ ASH34 → relay configured as DOC 123 is off

Else → maintains the status.

ASH34 = suction 1 temperature value at which the liquid injection valve is enabled (cooling action)

ASH35 = differential for ASH34

Decrease compressors discharge temperature (circuit 1): The temperature control parameter for discharge temperature is enabled, DSC 1 =YES (circuit 1, liquid injection valve activated also by discharge temperature). The 2 below conditions must be satisfied before starting the temperature check and control:

The temperature of the circuit 1 (MT) is monitored ONLY if at least one compressor of the circuit itself is running,

The temperature control starts after 1 minute after the start of the first compressor of the circuit.

At least one temperature probe, among the following ones, is set as discharge temperature probe, mounted on the discharge line:

AI XX = 156 “NTC discharge temperature line circuit 1”

AI XX = 158 “PTC discharge temperature line circuit 1”

AI XX = 69 “PTC discharge temperature compressor 1 circuit 1” or ……

AI XX = 80 “PTC discharge temperature compressor 12 circuit 1”

The relay configured as DOC XX = 123 “liquid injection valve circuit 1” works as a thermostat with direct action (cooling), using the temperature values coming from the probe sets as AI XX = 156, 158, 69, …, 80, respecting the following conditions:

If at least one of the probes ≥ DSC2 + DSC3 → relay configured as DOC 123 on

If all the probes ≤ DSC2 → relay configured as DOC 123 off

Else → maintains the status.

DSC2 = Circuit 1, discharge temperature threshold to activate the liquid injection valve

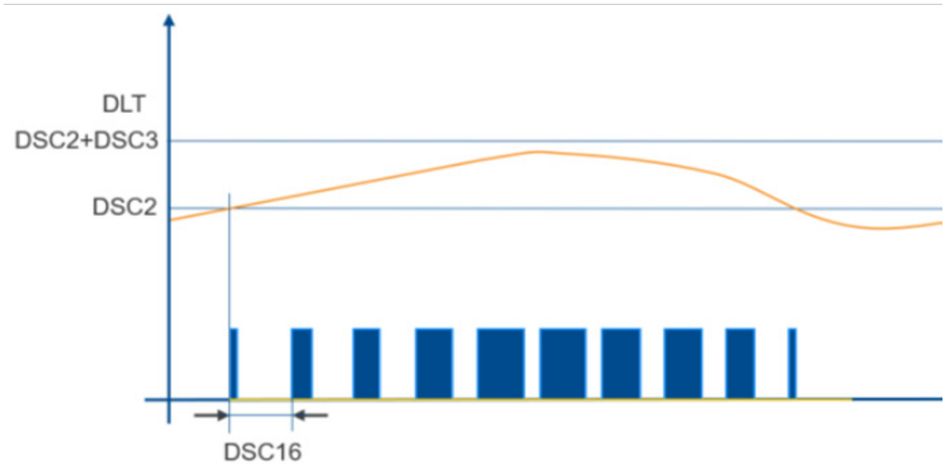
DSC3 = Circuit 1, Differential for DSC2 and DSC4

DSC4 = Circuit 1, High discharge temperature alarm, circuit 1

Liquid Injection Valve Control with PWM Action

Configuration is the same of previous paragraphs: activation to decrease superheat with high superheat conditions, activation to decrease suction temperature when it is too high, or activation to decrease discharge temperature when it is too high.

The PWM mode for discharge temperature control is enabled, DSC15 =YES (PWM action enable for liquid injection valve Circuit 1). The relay configured as liquid injection valve, DOC XX = 123, is activated in PWM mode, with minimum ON time of 1 second. The PWM cycle time for liquid injection valve Circuit 1, DSC16 can be set between 6–30 secs.



Oil Injection Management

XC-PRO can manage the solenoid valve connect oil separator with reservoir.

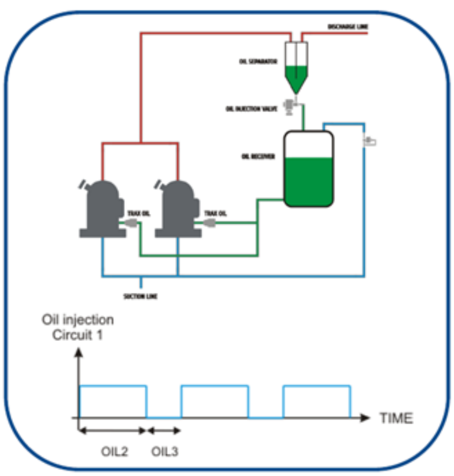
There are five possible configuration types, depending on the type of oil separator and reservoir used in the rack. Look at the below schema to set properly the kind of management:

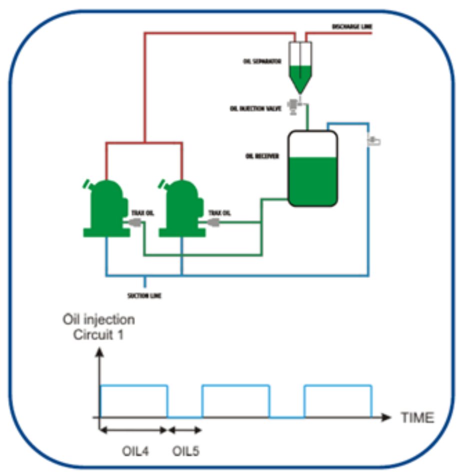
1. Oil separator and reservoir without low or high level inputs: the solenoid valve is managed according to the compressor status. (OIL1 = 1)
2. Oil separator with low level signal: the solenoid valve is managed according to the low level status. (OIL1 = 2)
3. Oil separator with low and high level signal: the solenoid valve is managed according to the status of both levels. (OIL1 = 3)
4. Oil management according to differential pressure between reservoir and medium temperature compressors and low level digital input in reservoir (OIL1 = 4)
5. Oil management according to differential pressure between reservoir and medium temperature compressors and low and high level digital inputs in reservoir (OIL1 = 5)

<u>OIL1 = 1, Oil Management According to Compressor Status</u>

When all the compressors are OFF in circuit 1 (MT) are ON the “oil injection valve of circuit 1” works in duty cycle mode according to OIL 2 (ON valve) and OIL 3 (OFF valve) timings.

When one or more compressors in circuit 1 (MT) are ON the “oil injection valve of circuit 1” works in duty cycle mode according to OIL 4 (ON valve) and OIL 5 (OFF valve) timings.





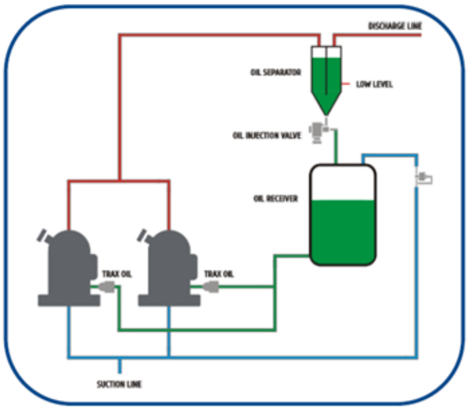
With OIL2 = 0 no injection is done.

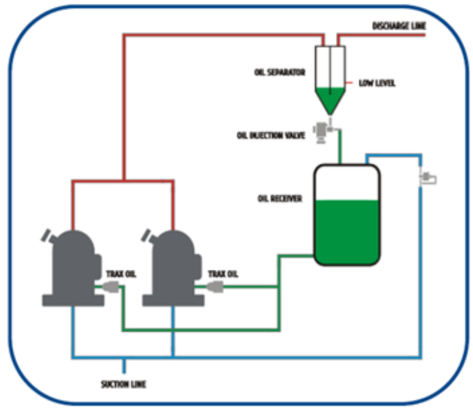
The same considerations and settings are available for circuit 2 (LT compressors).

<u>OIL1 = 2, Oil Management According to Low Level Digital Input in Oil Separator</u>

The oil injection valve works in duty cycle mode according to OIL 2 (ON valve) and OIL 3 (OFF valve) timings when low level digital input is not active and OIL10 (activation delay of oil injection valve circuit 1) timer in secs is ended.

If low level digital input is active the oil injection valve is switched OFF. When low oil level input is deactivated: controller wait the OIL10 timer is over, then the oil injection valve can cycle with OIL2 (ON valve) and OIL3 (OFF valve).





With OIL2 = 0 no injection is done.

The same considerations and settings are available for circuit 2 (LT compressors).

<u>OIL1 = 3, Oil Management According to Low and High Level Digital Inputs in Oil Separator</u>

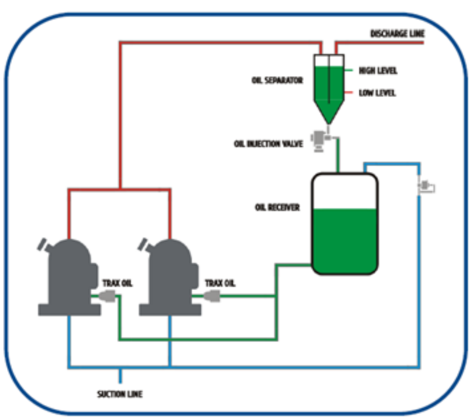
The oil injection valve works in duty cycle mode according to OIL 2 (ON valve) and OIL 3 (OFF valve) timings when low level digital input is not active and OIL10 (activation delay of Oil Injection valve circuit 1) timer in secs is over, independently from the status of high level digital input.

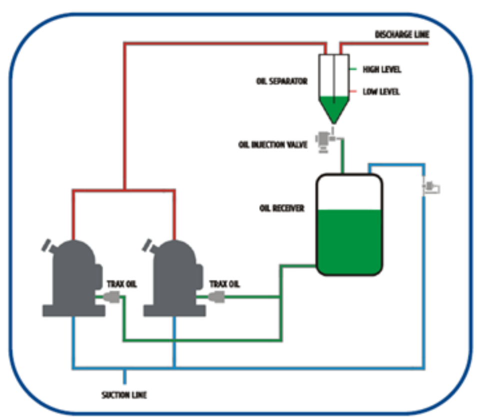
If high level switch in the oil separator is ON, after OIL24 cycles of oil injection we the follow warning is given:

“Full oil separator alarm”

If OIL24 = 0, none warning is signaled.

If low level digital input is active the oil injection valve is switched OFF. When low oil level input is deactivated: controller wait the OIL10 timer is over, then the oil injection valve can cycle with OIL2 (ON valve) and OIL3 (OFF valve).





<u>OIL1 = 4, Oil Management According to Differential Pressure and Low-Level Digital Switch in Oil Separator</u>

Normal function: presence of oil in the oil separator.

With the low oil level digital switch not active in the oil separator, and OIL10 timer over, the “oil injection valve circuit 1” works in duty cycle mode according to OIL 2 (ON valve) and OIL 3 (OFF valve) timings.

Differential Pressure Regulation

With OIL20 (reference probe for differential pressure) = oil receiver pressure - suction pressure (SPC1), or oil receiver pressure – flash tank pressure (FTP), if the differential pressure is not satisfied: OIL20 is lower than OIL 18 (pressure differential for oil management), the “oil injection valve circuit 1” works in duty cycle mode according to OIL 2 (ON valve) and OIL 3 (OFF valve) timings, independently from the status of low oil level switch.

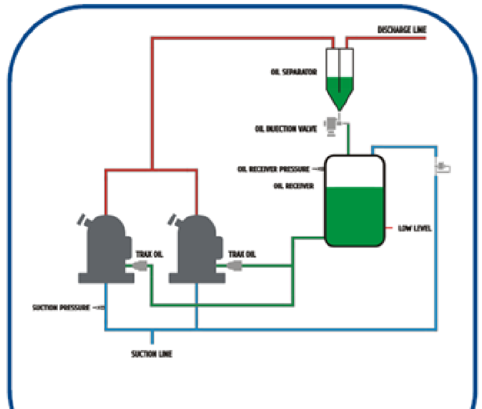


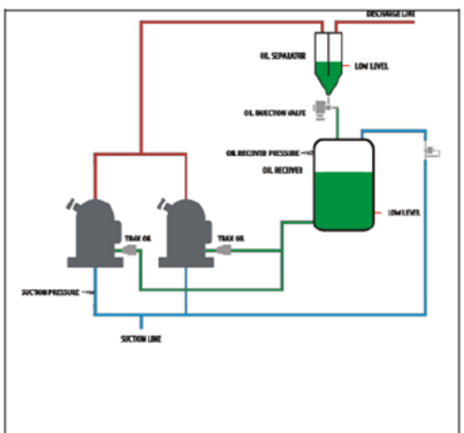
Figure 1

If the low-level switch is on, the “oil injection valve circuit 1” is stopped only if the differential pressure OIL20 is above OIL18 + OIL19 (differential for OIL18).

<u>Oil1 = 5, Oil Management According to Differential Pressure and with High and Low Level Digital Switches in Oil Separator and Low Level Switch in Reservoir</u>

Regulation is like in previous paragraph. In addition, the high oil level switch in oil separator can be set and considered (DIC XX = 162: High oil level in oil separator circuit 1).

With this input active, the controller performs OIL24 (number of retry for high level in oil separator) oil injection cycles, if after these cycles the high oil switch is still active, the alarm “oil separator full” is given.



OIL20 = SPC1

<u>Preventive Actions with Low Level Digital Input Active</u>

XC-PRO can try to improve oil quantity in the oil separator when it reaches low level. When the low-level oil digital input, in the oil separator, is active, to restore the correct lubrication and correct oil return, if OIL14 (action before low alarm level circuit 1) = 1 the inverter, if present and running, the inverter compressor is forced to run at max speed.

If the action is not enough, after the OIL12 delay time, the low oil level alarm will be activated, and the compressors can be stopped by setting OIL16 = 1.

If the pressure in oil receiver is above OIL27 (reservoir pressure threshold to stop oil injection valve circuit 1) the injection cycles will be immediately stopped.

Protocol CO_2

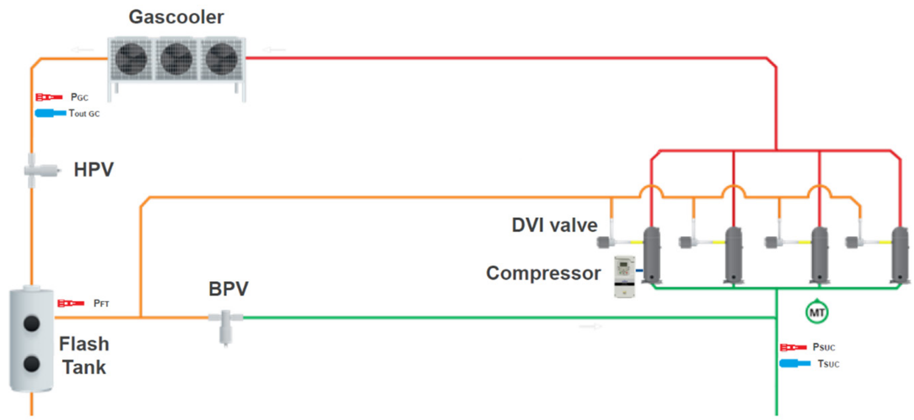
Operation and Controller

Transcritical Scroll CO_2 Management

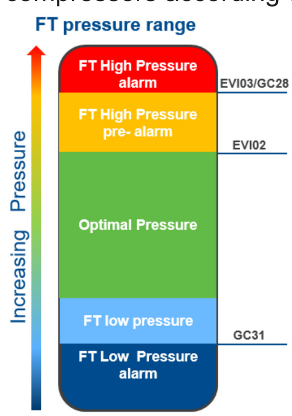
The XC Pro manages the transcritical scroll CO_2 compressor in 2 configurations:

- Flash tank DVI
- Eco DVI

Flash Tank DVI (Dynamic Vapor Injection Management with Flash Tank)



This solution is used when the liquid line can reach high pressure values (around or over 870 psig [60 bar]). The new components are the new transcritical scroll compressor and the DVI valve (one valve for each compressor installed and managed by dedicated digital output). DVI valve is a solenoid that allows to inject gas (or not) in the compressors according with the graphic bellow.



HPV	BPV	COMPRESSORS	DVI Valve
Close	Depending on Suction pressure	OFF	Close
Start closing	Start opening	Reduce capacity	Off with compressors
Standard regulation	Standard regulation Setpoint = EVI02- 3bar	Standard regulation	ON with compressors
Standard regulation	Close	Standard regulation	Close
Fix value (GC36 %)	Close	Standard regulation	Close

FT Low Pressure Alarm

- The HPV opens at fixed value GC36 (HPV % open during low pressure safety mode) and the BPV closes to increase the pressure into the flash tank.
- The compressor can work according to suction pressure value and discharge temperature value.
- It is not possible to inject flash gas by DVI valve into the compressor because the pressure is too low.

FT Low Pressure

- The HPV can work because the low-pressure alarm in the flash tank is ended. Pressure over GC31 (FT low-pressure setpoint).
- It is not possible to inject flash gas by DVI Valve into the compressor because the pressure is too low.
- The compressor can work according to suction pressure value and discharge temperature value.

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Optimal Pressure

- The HPV works to maintain the optimal pressure calculated according to the gas cooler outlet temperature.
- The BPV can work if the pressure will be over EVI02 - 3 bar, but it is usually closed. EVI02 (maximum flash tank pressure in standard regulation/BPV setpoint).
- The compressor can work and the DVI valve follows the compressor status. Open if compressor is ON and close if compressor is OFF.

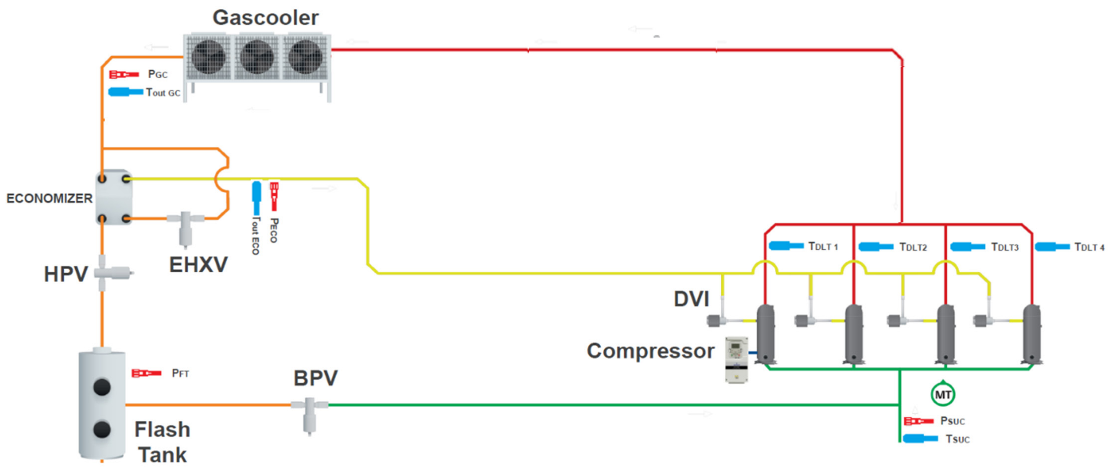
FT High Pressure Pre-Alarm

- The main actions of HPV and BPV are related to decrease the pressure into the flash tank.
- The compressor reduces the capacity to reduce the pressure in the gas cooler and the generation of flash gas.
- The DVI valve follows the compressor status. Open if compressor is ON and close if compressor is OFF.

FT High Pressure

- The main actions of HPV and BPV are related to decrease the pressure into the flash tank.
- The compressor is OFF and the DVI closed. EVI03 (flash tank pressure threshold to shut down compressor with EVI solenoid valve)/GC28 (FT high pressure setpoint).

Eco DVI (Dynamic Vapor Injection Management with Economizer)



Solution used when the liquid line cannot reach high pressure values (above 652 psig [45 bar]), therefore it allows to use the new compressor also in existing systems with old concept liquid lines. Same performance as the previous configuration (DVI solution). The new components are the economizer with pressure and temperature probes for SH calculation, the XEV20D for economizer EHXV valve management, the EHX valve and the compressor with the DVI valve (one valve for each compressor installed).

Operation and Controller

In standard condition the EHX valve works to maintain the right SH setpoint in the outlet of the economizer to have the possibly to inject vapor by DVI valve into the compressor.

In case of high pressure in the inlet of the DVI valve (economizer outlet) the EHX valve works to restore the right pressure for injection.

In case of high discharge temperature, the EHX valve works to decrease the discharge temperature.

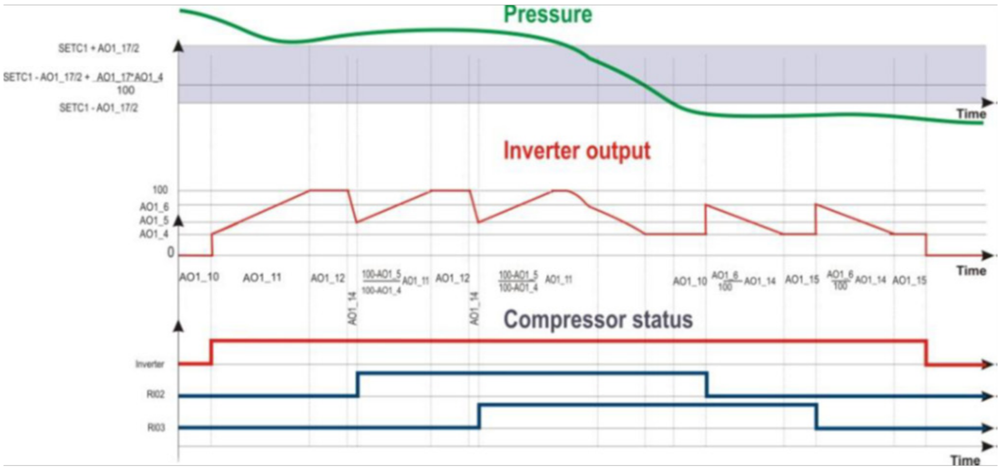
The parameters involved are:

Group	Parameter	Description	Value		Vis. Level	Limit		Unit
			Edit	Original		Minimum	Maximum	
EHXV CONTROL	EHX1	Minimum gas cooler pressure threshold to enable the EHXV regulation when the first EVI compressor starts	725	725	Pr1	650	1450	psi
EHXV CONTROL	EHX2	Minimum Gas cooler outlet temperature threshold to enable the EHXV regulation when the first EVI compressor starts	55	55	Pr1	-40	230	°F
EHXV CONTROL	EHX3	EHXV opening delay at compressor start	10	10	Pr1	0	255	sec
EHXV CONTROL	EHX4	Minimum allowed pressure at economizer (EHXP) to start injection into the port of the compressor	525	525	Pr1	290	755	psi
EHXV CONTROL	EHX5	Maximum allowed injection pressure at economizer (EHXP) for SH and DLT injection control	755	755	Pr1	525	855	psi
EHXV CONTROL	EHX6	Maximum allowed injection pressure at economizer (EHXP) for injection control	855	855	Pr1	755	1450	psi
EHXV CONTROL	EHX7	Discharge line temperature threshold enabling pressure and temperature control	250	250	Pr1	-40	266	°F
EHXV CONTROL	EHX8	Alarm discharge line temperature threshold	266	266	Pr1	250	284	°F
EHXV CONTROL	EHX9	Discharge line temperature threshold to stop regulation	284	284	Pr1	266	302	°F
EHXV CONTROL	EHX10	Analog output %variation when EHXP > EHX6	10	10	Pr1	0	100	%
EHXV CONTROL	EHX11	Time interval to decrease the analog output when EHXP > EHX6	5	5	Pr1	1	60	sec
EHXV CONTROL	EHX12	Differential for minimum allowed pressure at economizer (EHXP) to disable EVI of the compressor	30	30	Pr1	-72	72	psi

Group	Parameter	Description	Value		Vis. Level	Limit		Unit
			Edit	Original		Minimum	Maximum	
EHXV SH CONTROL	SHX1	SH set point for EHXV	18	18	Pr1	1	40	DDF
EHXV SH CONTROL	SHX2	Proportional band	20	20	Pr1	1	108	DDF
EHXV SH CONTROL	SHX3	Dead band for superheat regulation	-2	-2	Pr1	-50	50	DDF
EHXV SH CONTROL	SHX4	EHX SH set point used with DLT = EHX8	4	4	Pr1	1	18	DDF
EHXV SH CONTROL	SHX5	Integration time	240	240	Pr1	0	1000	sec
EHXV SH CONTROL	SHX6	Derivative step	0	0	Pr1	0	255	step
EHXV SH CONTROL	SHX7	Probe Error opening percentage	17	17	Pr1	0	100	%
EHXV SH CONTROL	SHX8	Start Function duration	2.0	2.0	Pr1	0.0	42.0	min
EHXV SH CONTROL	SHX9	Start opening Percentage	0	0	Pr1	0	100	%
EHXV SH CONTROL	SHX10	Minimum opening percentage at normal Functioning	0	0	Pr1	0	46	%
EHXV SH CONTROL	SHX11	Maximum opening percentage at normal Functioning	46	46	Pr1	0	100	%

VSD Compressor Management

The analog output can be used in a rack with VSD compressor, driven by an inverter. The regulation of the compressors in this case is changed as described in the following graph:



AO1_4	Minimum value for Analog Output1	0 ÷ 99 %
AO1_5	Analog Output1 value after compressor on	AO1_4 ÷ 100 %
AO1_6	Analog output1 value after compressor off	AO1_4÷ 100 %
AO1_10	Regulation delay after entering the regulation band	0 ÷ 255 (sec)
AO1_11	Analog output 1 rise time from AO1_4 to 100% when the pressure is above the regulation band and a load is switched on	0 ÷ 255 (sec)
AO1_12	Analog output 1 permanency at 100% before load activation	0 ÷ 255 (sec)
AO1_13	Delay between pressure (temperature) goes down the set point and start of analog Output 1 decreasing	0 ÷ 255 (sec)
AO1_14	Analog Output1 decreasing time, from 100% to AO1_5 when a load is switched on	0 ÷ 255 (sec)
AO1_15	Analog Output1 permanency at AO1_4 before a load is switched off	0 ÷ 255 (sec)
AO1_16	Analog Output 1 decreasing time from 100% to the AO1_4 value	0 ÷ 255 (sec)
AO1_17	Proportional band for inverter regulation	0 ÷ 255 (sec)

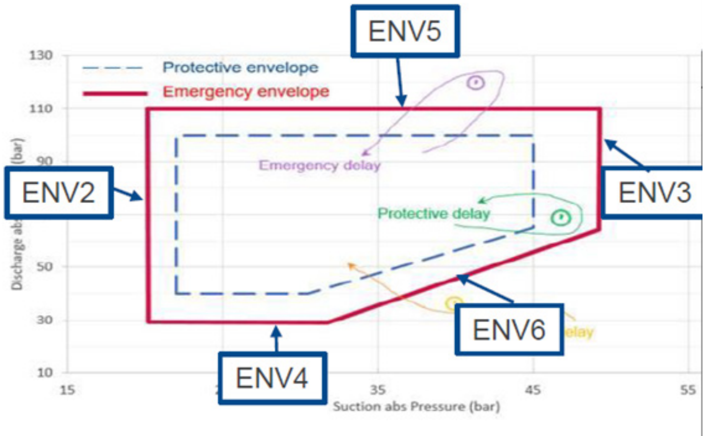
Parameter	Description	Value		Vis. Level	Limit		Unit	Comment
		Edit	Original		Minimum	Maximum		
AO1_1	Probe for analog output 1	Pb1	Pb1	Pr1				Not used
AO1_2	Lower limit for analog output 1	-40.0	-40.0	Pr1	-70.0	150.0	°C	Not used
AO1_3	Upper limit for analog output 1	110.0	110.0	Pr1	-70.0	150.0	°C	Not used
AO1_4	Minimum value for analog output 1	0	0	Pr1	0	100	%	Min speed for inveter compressor
AO1_5	Analog output 1 value after load start	50	50	Pr1	0	100	%	Inverter compressor speed before fix speed compressor activation
AO1_6	Analog output 1 value after load off	50	50	Pr1	0	100	%	Inverter compressor speed before fix speed compressor deactivation
AO1_7	Exclusion band start value 1	49	49	Pr1	0	49	%	Exclusion band for noise or vibration
AO1_8	Exclusion band end value 1	49	49	Pr1	49	99	%	Exclusion band for noise or vibration
AO1_9	Safety value for Analog output 1	80	80	Pr1	0	100	%	Value speed for the compressor inverter in case of pressure probe error
AO1_10	Regulation delay after exit from neutral zone	20	20	Pr1	0	255	sec	Delay time for inveter compressor activation
AO1_11	Analog output 1 rise time from minimum value to 100%	120	120	Pr1	0	255	sec	Ramp UP time
AO1_12	Analog output 1 permanency before load activation	30	30	Pr1	0	255	sec	Delay with inverter at max speed (AOx_13) before fix speed compressor activation
AO1_13	Max value for analog Output 1	100	100	Pr1	0	100	%	Max % speed for inverter compressor
AO1_14	Analog output 1 decreasing time after load off	30	30	Pr1	0	255	sec	Ramp DOWN time
AO1_15	Analog output 1 permanency before load off	10	10	Pr1	0	255	sec	Dealy with inverter at min speed (AOx_4) befor fix speed compressor deactivation
AO1_16	Analog output 1 decreasing time from 100% before load on	10	10	Pr1	0	255	sec	Ramp DOWN time from max speed
AO1_17	Regulation band width 1	6.0	6.0	Pr1	0.0	25.0	°C	Proportional band for PI settings
AO1_18	Integral time 1	220	220	Pr1	0	999	sec	Integral time for PI settings
AO1_19	Band offset 1	0.0	0.0	Pr1	-12.0	12.0	°C	Offset for proportional band

Protocol CO_2
Operation and Controller

Compressor Envelope Management

With the parameters ENV11 (envelope index for circuit 1) and ENV12 (envelope index for circuit 2) it is possible to enable the compressor envelope management for both temperature lines (MT and LT).

When the envelope protection is enabled the max gas cooler pressure set point is the minimum value between GC13 (maximum allowable pressure setpoint in gas cooler) and max gas cooler pressure output from envelope.



Group	Parameter	Description
ENVELOPE	ENV1	Alarm delay for inverter compressor circuit 1 in special low evap region
ENVELOPE	ENV2	Delay before shutdown inverter compressor circuit 1 when evap temperature/pressure < Absolute Min evap temperature/pressure
ENVELOPE	ENV3	Delay before shutdown inverter compressor circuit 1 when evap temperature/pressure > Absolute Max evap temperature/pressure
ENVELOPE	ENV4	Delay before shutdown inverter compressor circuit 1 when cond temperature/pressure < Absolute Min cond temperature/pressure
ENVELOPE	ENV5	Delay before shutdown inverter compressor circuit 1 when cond temperature/pressure > Absolute Max cond temperature/pressure
ENVELOPE	ENV6	Alarm delay for inverter compressor circuit 2 in special low evap region
ENVELOPE	ENV7	Delay before shutdown inverter compressor circuit 2 when evap temperature/pressure < Absolute Min evap temperature/pressure
ENVELOPE	ENV8	Delay before shutdown inverter compressor circuit 2 when evap temperature/pressure > Absolute Max evap temperature/pressure
ENVELOPE	ENV9	Delay before shutdown inverter compressor circuit 2 when cond temperature/pressure < Absolute Min cond temperature/pressure
ENVELOPE	ENV10	Delay before shutdown inverter compressor circuit 2 when cond temperature/pressure > Absolute Max cond temperature/pressure
ENVELOPE	ENV11	Envelope Index for circuit 1
ENVELOPE	ENV12	Envelope Index for circuit 2
ENVELOPE	ENV13	Delay before shutdown inverter compressor circuit 1 when emergency envelope alarm occurs
ENVELOPE	ENV14	Delay before shutdown inverter compressor circuit 2 when emergency envelope alarm occurs
ENVELOPE	ENV15	Delay before shutdown inverter compressor circuit 1 when compressor starts out from envelope
ENVELOPE	ENV16	Delay before shutdown inverter compressor circuit 2 when compressor starts out from envelope

Case Controller

The evaporator case controller (CC) maintains the air temperature and superheat by modulating an electronic expansion valve. The CC has a max operating pressure (MOP) so if the suction pressure is too high (e.g., 30° F SST) the case controller will close the EEV. Once the suction pressure falls below the MOP setpoint, the EEV will be allowed to open to maintain the air temperature or superheat. Case controllers typically includes setpoints to manage the superheat when the superheat falls within the operational band and a close fail safe setpoint.

Parameter	Value	Unit	Remarks
LT case controller mop setpoint	290	psig	typical setpoint
MT case controller mop setpoint	465	psig	typical setpoint
case controller superheat	8–20	° F	typical operating superheat
case controller superheat band	8–15	° F	typical superheat band range
case controller superheat cutout	4	° F	typical superheat cutout setpoint

⚠WARNING

READ ALL WARNINGS AND PROCEDURES IN THIS MANUAL AND ON THE UNIT BEFORE SERVICING OR PERFORMING MAINTENANCE ON THIS EQUIPMENT.

FAILURE TO ABIDE BY THESE WARNINGS COULD RESULT IN AN EXPLOSION, DEATH, INJURY, AND PROPERTY DAMAGE.

Checks and Repairs to Electrical Devices

- Repair and maintenance to electrical components shall include initial safety checks and component inspection procedures. If a fault exists that could compromise safety, then no electrical supply shall be connected to the circuit until it is satisfactorily dealt with. If the fault cannot be corrected immediately but it is necessary to continue operation, an adequate temporary solution shall be used. This shall be reported to the owner of the equipment,
  so all parties are advised.
- Initial safety checks shall include:

  a. That capacitors are discharged: this shall be done in a safe manner to avoid possibility of sparking
  b. That no live electrical components and wiring are exposed while charging, recovering or purging the system
  c. That there is continuity of earth bonding

Refrigerant Charging Procedure

A calibrated scale with +/-2 gram accuracy must be used to charge the system. The charge amount is shown on the serial plate. Only refrigerant-grade R-744 (CO_2) refrigerant should be used.

No gas charge adjustments are allowed. When connecting hoses between the refrigeration system, manifold gauges, and refrigerant cylinder, ensure that the connections are secure and there are no potential sources of ignition nearby. Ensure that contamination of different refrigerants does not occur when using charging equipment.

Use dedicated hoses to service refrigeration systems. Hoses or lines should be as short as possible to minimize the amount of refrigerant contained in them.

Ensure that the refrigeration system is properly grounded prior to charging the system with refrigerant, to avoid the potential for static build-up.

In addition to conventional charging procedures, the following requirements shall be followed:

a. Ensure that contamination of different refrigerants does not occur when using charging equipment. Hoses or lines shall be as short as possible to minimize the amount of refrigerant contained in them.
b. Cylinders shall be kept in an appropriate position according to the instructions.
c. Ensure that the REFRIGERATING SYSTEM is earthed prior to charging the system with refrigerant.
d. Label the system when charging is complete (if not already).
e. Extreme care shall be taken not to overfill the REFRIGERATING SYSTEM.

Prior to recharging the system, it shall be pressure-tested with the appropriate purging gas. The system shall be leak-tested on completion of charging but prior to commissioning. A follow up leak test shall be carried out prior to leaving the site.

Extreme care must be taken not to overfill the refrigeration system. After charging, carefully disconnect the hoses, attempting to minimize the quantity of refrigerant released. Further leak check the service ports, hoses, refrigerant tanks.

Thoroughly leak check the service ports. If no leak is present, use a pinch-off tool to close the ends of the service tubes before brazing them shut. If a Schrader valve is used on the compressor service tube, it must be removed and the previous steps followed in order to braze the service tube shut.

Oil Changes

Oil changes should be accomplished following the procedure below: See Temprite step-by-step instructions for 133A, 135A, 137A, 138A, and 139A series coalescent oil separators.

Temprite

Installation Instructions for Models 133A, 135A, 137A, 138A,139A Accessible Coalescent Oil Separators

130 Series coalescent oil separators have a factory-installed Standard Filter. Remember: Temprite Standard Filters pick up all dirt and particulates down to 0.3 microns; typical filters catch only 50 microns or larger.

1. Locate the separator in a warm, draft-free area, or wrap separator with insulation.
2. Install the separator in a vertical position, close to the compressor, in between compressor and condenser, upstream (before) any bypass piping.
3. Special consideration should be given to the location so that future filter replacement or service is not impeded.
4. Clamp and support the separator and piping properly to minimize vibration.
5. Discharge lines into and out of the separator must be the same size as the separator connection size.
6. Install pressure taps in these lines for reading pressure drop across the separator.
7. Charge the separator with the recommended amount of oil through the oil return connection before installing or starting the system.
8. If the oil separator is lower than the condenser, take precautions to keep liquid refrigerant out of the separator.
9. Frequently check oil level and pressure drop across the separator on new installations.
10. Change the filter after an initial 24 to 48 hours of operation or if the pressure drop across the separator exceeds 13 PSI/0.9 bar. See filter replacement instructions.
11. Change the filter if dirt loading causes a pressure drop of 13 PSI/0.9 bar differential across the separator.

For translations of these instructions, go to our website: click here or scan the QR code.

Questions? Call 1-800-552-9300 or 630.293.5910 or email us at temprite@temprite.com

8–12 Hours After Startup

1. After the Protocol has run loaded 100%, clean the oil supply line strainer.
2. Verify all evaporators and compressor superheats for any flood-back and resolve.
3. Check for excessive pressure drops (assuming all circuits are running).
4. Under normal operating conditions, measure and record compressor amp draw.
5. Measure and record defrost electric heaters.
6. Review compressor cycle counts not to exceed 6 starts per hour.
7. Review HPV & FGB for excessive modulation.
8. Verify oil separator drain solenoid is cycling and draining properly.
9. After a shutdown, verify circuits are staged sequentially without excessive increase in suction pressure. If excessive pressure increase occurs, adjust staging sequence accordingly.
10. Leak test the Protocol, gas cooler and piping with a CO_2 leak detector.
11. Verify all defrost lengths, times, and scheduling across the 24 hour day is appropriate.
12. Always check that each case after defrost the temperature exceeds 32° F (0° C) in the evaporator and the coil is clear.
13. If the coil is not clearing using the recommended defrost settings, call Hussmann for review.
14. Ensure that all the programming is finished and well understood by the servicing contractor.
15. Ensure that all temperature sensors and pressure sensors are well calibrated.
16. Ensure all control panels are closed.
17. Record CO_2 level in flash tank for future reference (e.g., bottom sight glass, center sight glass, etc.).
18. Fill out the startup form and send it to Hussmann no later than three weeks after start up.
19. Check the pressure drop across the oil separator. Replace if it exceeds 10 psigd.

48 Hours After Startup

1. After the Protocol has run loaded 100%, clean the oil supply line strainer.
2. Verify all evaporators and compressor superheats for any flood-back and resolve.
3. Review compressor cycle counts, not to exceed 6 starts per hour.
4. Verify oil separator drain solenoid is cycling and draining properly.
5. Record CO_2 level in flash tank for future reference. (e.g., bottom sight glass, center sight glass, etc.)
6. Replace both liquid and suction filters.
7. Test oil for moisture and acid contamination.
8. Check the pressure drop across the oil separator. Replace if it exceeds 10 psigd.

30 Days After Startup

1. After the Protocol has run loaded 100%, clean the oil supply line strainer.
2. Verify all evaporators and compressor superheats for any flood-back and resolve.
3. Review compressor cycle counts, not to exceed 6 starts per hour.
4. Verify oil separator drain solenoid is cycling and draining properly.
5. Record CO_2 level in flash tank for future reference. (e.g., bottom sight glass, center sight glass, etc.)
6. Replace liquid core.

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Compressor Replacement

Since each machine room or rooftop unit tends to be unique, plan carefully as to how you will move the compressor without harming personnel, equipment or the building. Before beginning removal of an old compressor make replacement unit ready to install:

1. Verify replacement compressor electrical requirements, refrigerant, application, capacity, piping hookup location, and design suction and discharge gaskets.
2. Mounting requirements: Have compressor in an easily accessible position, uncrated, and unbolted from shipping pallets.
3. Disconnect electrical supply: Turn off motor and control panel power supplies to the Protocol. Turn off control circuit and open all compressor circuit breakers. Tag and remove electrical wires and conduit from the compressor.
4. Isolate compressor from Protocol: Front seat suction and discharge service valves. Close oil supply and equalizing lines. Bleed compressor pressure through both discharge and suction access ports into an approved recovery vessel.
5. Remove oil supply and equalizing lines. Remove externally mounted components which will be re-used on the replacement compressor. Plug holes to compressor manufacturer's specifications.
6. Remove bolts from suction and discharge service valves.
7. Remove mounting bolts: When moving the compressor, use a come-along, hoist, or hydraulic lift to carry the weight.

WARNING: Do not use the Protocol piping or panel to support a hoist or come along.
WARNING: Do not use ceiling trusses to support a hoist or come along.

The rear support channel on the Protocol or a properly constructed ceiling rail may be used to support a hoist or come along. To make hookup and lifting easier, an eye bolt may be installed in the rear top of the compressor head.

If a compressor removal table is used, slide the compressor fully on to the table then roll table to overhead hoist or hydraulic lift area. When the old compressor has been removed, clean the suction and discharge service valve gasket surfaces to shiny metal. Clean the gasket surfaces on the new compressor to shiny metal. Be careful not to groove or round the surfaces. Gasket surfaces must be clean to prevent leaking.

Install the new compressor in reverse order of removal. Do not open the new compressor to the system until after it has been leak tested and triple evacuated.

Oil level regulator sight glasses are designed to provide a hermetic seal when internally pressurized.

Some leaking may occur when a deep vacuum is pulled.

Avoid unnecessary disassembly of unused fittings.

Use only long reducers in female Swagelok end connections.

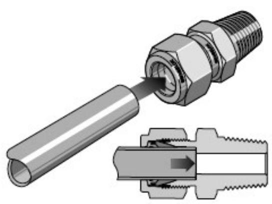
Swagelok End Connection

Original Copeland CO_2 scroll compressors use a discharge check valve fitted inside the discharge port and rubber plugs fitted to the suction and discharge ports as standard. The thread connections on the service valves are Swagelok connections. The following safety precautions must be considered when using that type of connection:

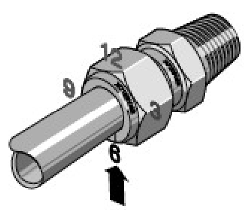
- Do not bleed system by loosening fitting nut or fitting plug.
- Do not assemble and tighten fittings when system is pressurized.
- Make sure that the tubing rests firmly on the shoulder of the tube fitting body before tightening the nut.
- Use the correct Swagelok gap inspection gauge to ensure sufficient pull-up upon initial installation.
- Always use proper thread sealants on tapered pipe threads.
- Do not mix materials or fitting components from various manufacturers tubing, ferrules, nuts, and fitting bodies.
- Never turn fitting body. Instead, hold fitting body and turn nut.
- Avoid unnecessary disassembly of unused fittings.
- Use only long reducers in female Swagelok end connections.

Swagelok Installation

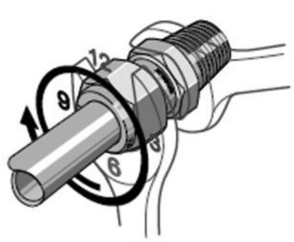
1. Fully insert the tube into the fitting and against the shoulder; rotate the nut finger tight. Further tighten the nut until the tube can no longer be turned by hand or move axially in the fitting.



2. Mark the nut at the 6 o'clock position.



3. While holding the fitting body steady, tighten the nut one and one-quarter turns position.



NOTE: More information about adapters and shut-off valves can be found in the Copeland Spare Parts Catalog available at www.copeland.com/en-gb/tools-resources

Protocol CO_2

Maintenance and Service

General Maintenance

Regular inspection and upkeep is critical to operation of the Protocol. Because of the numerous options and accessories that are unique to each store, it is impossible to list all the maintenance guidance for individual systems.

Maintenance must be performed by a well-qualified technician to diagnose and prevent problems before they may occur. The information below is a general guideline. Recommended service intervals in your area may vary depending on the operating environment and equipment used. Contact your Hussmann representative for further information.

Generally, the following items should be checked on a weekly basis:

- System pressures
- Main power voltage
- Oil levels
- Flash tank CO_2 level

Generally, the following items should be checked on a monthly basis:

- Oil separator pressure drop
- System pressures
- System leak tests
- All filters and drier cores
- Insulation, conduit, electrical boxes, and control panels
- Secondary systems and accessories
- Fan motors, contactors, and electrical connections
- Check for tightness of fittings, fan blades, and motor mounts

Generally, the following items should be checked on a quarterly basis:

- Investigate operating conditions for the following:
- Suction, liquid, and discharge pressures and temperatures
- Sub-cooling, superheat, and ambient temperatures
- Safety controls, operating controls, and alarms
- Amperage coming from compressors

Each year, check the following:

- Clean the gas cooler coil or pads when applicable in accordance with the manufacturer’s instructions
- Straighten or replace all fan blades
- Change the filter drier and suction cores
- Get an oil sample and determine the quality and change if required

Replacement of Drier And Filter Cores

Isolate the core to be replaced and bleed off pressure to outside. Open housing, replace core, and close up. Pressurize, leak test, and bring back into line.

Component Reference Documents

Parker Sporlan Literature Site

Mobile Apps for Emerson Product Support

Sporlan MTW Valve

Sporlan EEV

Emerson OMB Oil Control

Westermeyer Liquid Level

Danfoss

Kriwan / Delta Oil Switch

Kriwan / Delta Oil Sensor

Temprite Coalescent Oil Separator

Standard Filter Install

Temprite Clean Up

CPC

VFD M-400 Parameter Sheet

POP-OFF Pressure Relief Valves

- Mueller A15504-650 - Hussmann p/n 3084831

Compressors

Part Number	Description
3166388	SCROLL 3 PH 16.6 A 400 V 50 Hz CO_2
3176056	SCROLL 3 PH ZTI21AG-TFD-297
3155581	SCROLL 3 PH 26.4 A 400 V 50 Hz CO_2
3176057	SCROLL 3 PH ZTI36AG-TFD-297
3194220	SCROLL 3 PH ZTW21AG-4X9-297
3194219	SCROLL 3 PH ZTW28AG-4X9-297
3155580	SCROLL 3 PH 56 A 400 V 50 Hz CO_2

Refrigerant Removal, Evacuation, and Recovery

When breaking into the refrigerant circuit to make repairs—or for any other purpose—conventional procedures shall be used. The following procedure shall be adhered to:

a. Safely remove refrigerant following local and national regulations
b. Purge the circuit with inert gas
c. Evacuate
d. Purge with inert gas
e. Open the circuit by cutting or brazing.

The refrigerant charge shall be recovered into the correct recovery cylinders if venting is not allowed by local and national codes. Compressed air or oxygen shall not be used for purging refrigerant systems.

Refrigerants purging shall be achieved by breaking the vacuum in the system with oxygen-free nitrogen and continuing to fill until the working pressure is achieved, then venting to atmosphere, and finally pulling down to a vacuum. This process shall be repeated until no refrigerant is within the system. When the final oxygen-free nitrogen charge is used, the system shall be vented down to atmospheric pressure to enable work to take place.

Ensure that adequate ventilation is available.

Recovery Procedure

When removing refrigerant from a system, either for servicing or decommissioning, it is recommended good practice that all refrigerants are removed safely. When transferring refrigerant into cylinders, ensure that only appropriate refrigerant recovery cylinders are employed. Ensure that the correct number of cylinders for holding the total system charge is available.

All cylinders to be used are designated for the recovered refrigerant and labeled for that refrigerant (i.e., special cylinders for the recovery of refrigerant). Cylinders shall be complete with pressure-relief valve and associated shut-off valves in good working order. Empty recovery cylinders are evacuated and, if possible, cooled before recovery occurs.

The recovery equipment shall be in good working order with a set of instructions concerning the equipment that is at hand and shall be suitable for the recovery of all appropriate refrigerants including. In addition, a set of calibrated weighing scales shall be available and in good working order. Hoses shall be complete with leak-free disconnect couplings and in good condition. Before using the recovery machine, check that it is in satisfactory working order, has been properly maintained and that any associated electrical components are sealed to prevent ignition in the event of a refrigerant release. Consult manufacturer if in doubt.

The recovered refrigerant shall be returned to the refrigerant supplier in the correct recovery cylinder, and the relevant waste transfer note arranged. Do not mix refrigerants in recovery units and especially not in cylinders.

If compressors or compressor oils are to be removed, ensure that they have been evacuated to an acceptable level. The evacuation process shall be carried out prior to returning the compressor to the supplier. Only electric heating to the compressor body shall be employed to accelerate this process.

When oil is drained from a system, it shall be carried out safely.

Protocol CO_2

Decommissioning

Decommissioning Process

Before carrying out this procedure, it is essential that the technician is completely familiar with the equipment and all its details. It is recommended good practice that all refrigerants are recovered safely. Prior to the task being carried out, an oil and refrigerant sample should be taken in case analysis is required prior to re-use of recovered refrigerant. It is essential that electrical power is available before the task is commenced.

a. Become familiar with the equipment and its operation.
b. Isolate the system electrically.
c. Before attempting the procedure, ensure:
   i. Mechanical handling equipment is available, if required, for handling refrigerant cylinders.
   ii. All personal protective equipment is available and being used correctly.
   iii. The recovery process is supervised at all times by a qualified, competent person.
   iv. Recovery equipment and cylinders conform to the appropriate standards.
d. Pump down refrigerant system, if possible.
e. If a vacuum is not possible, make a manifold so that refrigerant can be removed from various parts of the system.
f. Make sure that cylinder is situated on the scales before recovery takes place.
g. Start the recovery machine and operate in accordance with instructions.
h. Do no overfill cylinders (no more than 80% volume liquid charge).
i. Do not exceed the maximum working pressure of the cylinder, even temporarily.
j. When the cylinders have been filled correctly and the process completed, make sure that the cylinders and the equipment are removed from site promptly and all isolation valves on the equipment are closed off.
k. Recovered refrigerant shall not be charged into another refrigerating system unless it has been cleaned and checked.

Equipment shall be labeled stating that it has been decommissioned and emptied of refrigerant. The label shall be dated and signed.

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Warranty

To obtain warranty information or other support, contact your Hussmann representative or visit: https://www.hussmann.com/services/warranty.

Please include the model and serial number of the product.

For questions about your equipment, please contact our Technical Support Team at 1-866-785-8499

For general support or service calls, contact our Customer Support Call Center at 1-800-922-1919

For ordering aftermarket warranty parts, call 1-855-HussPrt (1-855-487-7778) or email the following address: Hussmann_part_warranty@hussmann.com

Square D Tech Support Hotline 888-SQUARED (888-778-2733)
Level one provides product initial tech support and can connect the caller to level two if required.

Revision History

Revision A: (April 2025) Initial release

Scan the QR code on your mobile device to access additional product information or order parts using unit serial number.

Parts may also be ordered at:
parts.hussmann.com
Call toll free: 1.855.487.7778

U.S. & Canada 1-800-922-1919 • Mexico 800-890-2900 • www.hussmann.com