



# ZERO ZONE

## REFRIGERATION SYSTEMS

Installation, Operation, & Maintenance Manual



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# ZERO ZONE WARRANTY

## Limited Warranty

Zero Zone, Inc. (Seller) hereby warrants that any products manufactured by it and sold are warranted to be free from defects in material and workmanship, under normal use and service for its intended purpose, for a period of one (1) year from the date of original installation (not to exceed 15 months from the date of factory shipment). Zero Zone ChillBrite® LED Lighting carries a 5-year parts warranty. Zero Zone CoolView® Doors carry a 10-year glass pack parts warranty. The obligation under this warranty shall be limited to repairing or exchanging any part, or parts, FOB Factory, which is proven to the satisfaction of the Zero Zone Service Department to be defective. Zero Zone reserves the right to inspect the job site, installation, and reason for failure. This limited warranty does not cover labor, freight, or loss of food or product, including refrigerant loss. This warranty does not apply to motors, switches, controls, lamps, driers, fuses, or other parts manufactured by others and purchased by the Seller unless the manufacturer of these items warrants the same to the Seller, and then only to the extent of those manufacturer's warranty to the Seller. Any products sold on an "AS IS" basis shall not be covered by this warranty.

## Extended Warranties

In addition to the standard limited warranty, for further consideration, the Seller will extend to the original purchaser prior to shipment, a limited extended warranty on the compressor only, following expiration of the standard warranty. The Seller agrees to repair or exchange, at its option, or provide reimbursement for such exchange as directed, less any credit allowed for return of the original compressor, of a compressor of like or similar design and capacity, if it is shown to the satisfaction of Zero Zone that the compressor is inoperative due to defects in factory workmanship or material under normal use and services as outlined by Zero Zone in its Installation & Operation Manuals and other instructions.

## Length of Extended Warranty

Any compressor warranty may be extended for an additional four (4) years, but such extension must be purchased prior to shipment to be effective. This warranty is only for the compressor and not for any other associated parts of the refrigeration system.

## Product Not Manufactured by the Seller

The written warranty, if any, provided by the manufacturer of any part of the refrigeration unit sold by Seller to Buyer, but not manufactured by Seller, is hereby assigned to the Buyer. However, Seller makes no representation or warranty regarding the existence, validity, or enforceability of any such written warranty.

## Limitation and Exclusion of Warranties

THE WARRANTIES SET FORTH HEREIN ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES AND REMEDIES WHATSOEVER, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE.



# INTRODUCTION

## Important User Information

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The information in this manual is subject to change without notice and does not represent a commitment on the part of Zero Zone. Zero Zone does not assume any responsibility for any errors that may appear in this manual. In no event will Zero Zone be liable for technical or editorial omissions made herein, nor for direct, indirect, special, incidental, or consequential damages resulting from the use or defect of this manual.

The information in this document is not intended to cover all possible conditions and situations that might occur. The end user must exercise caution and common sense when installing, using, or maintaining Zero Zone products. If any questions or problems arise, call Zero Zone at 800-708-3735.

Any change to a Zero Zone product made during the installation, start-up, or at any other time must be submitted in writing to Zero Zone for approval and be approved by Zero Zone in writing prior to commission. The product warranty is voided when any unapproved change is made to a Zero Zone product.

## Manufacturer

**Zero Zone, Inc.**  
**Refrigeration Systems Division**

6151 140th Ave NW • Ramsey, MN 55303 • 800-247-4496 • [www.zero-zone.com](http://www.zero-zone.com)

## Intended Use

Zero Zone products are intended to be installed and used as described in this manual and other related Zero Zone literature, specifications, drawings, and data. All Zero Zone products must be leveled after being installed.

## Notice to Refrigeration Contractor

The Zero Zone Refrigeration Systems Manual includes nominal settings to allow the contractor to start the equipment. The contractor is responsible for reviewing the operation of equipment following start-up and for making necessary adjustments.

Authorization and approval from Zero Zone, Inc. must be obtained before any warranty rework or repairs are done to any products provided by Zero Zone, Inc. Authorization consists of obtaining a rework number from the Zero Zone Service Department. Labor charged to be at same rate as installation rate and/or rate standards. Zero Zone, Inc. reserves the right to furnish materials necessary to make repairs or authorized changes.

Failure to comply with these requirements may void the warranty and charges for repairs or rework may be denied.

Please contact us at 800-708-3735 if you have any questions or concerns.

This manual covers general instructions for Zero Zone refrigeration systems. For more information about individual pieces of equipment, refer to the manufacturer's literature.

# SAFETY

## Safety Symbols

Beware of possible unsafe conditions when you see the warning symbol. Warning levels may be shown as danger, warning, or caution:



**DANGER!** APPLIES TO A CONDITION THAT WILL RESULT IN DEATH OR SERIOUS INJURY.



**WARNING!** APPLIES TO A CONDITION THAT CAN RESULT IN SERIOUS INJURY OR DAMAGE TO EQUIPMENT.



**CAUTION!** APPLIES TO A CONDITION THAT CAN RESULT IN MODERATE INJURY OR DAMAGE TO EQUIPMENT OR PRODUCT.

## General Safety

Do not service or operate the equipment without reading and understanding the important information and warnings within this manual. Ignoring these warnings can result in death, serious injury, or damage to the system and product. Follow all applicable safety guidelines in all circumstances. This includes, but is not limited to, NEC, OSHA, and national/state/local regulations.

Only qualified and trained personnel should perform maintenance or repairs. The personnel must understand all of the main parts, controls, safety features, correct operation, and inspection procedures of the equipment before operating it. Shut off the electric power following your company's lock-out/tag-out procedure when performing maintenance on the electrical equipment. Do not modify the equipment unless it is approved in writing by Zero Zone, Inc.

Only operate the equipment under the specified conditions and manner. Always look for equipment damage during operation. If damage is found, safely shut down the equipment and correct the damage before continuing operation. Do not operate the equipment after an inspection reveals a possible safety hazard or if any equipment parts require maintenance or replacement. Do not bypass, disconnect, or ignore safety and warning devices of the system.

Further safety information can be found within this manual or other manufacturer's manuals. Please contact Zero Zone, Inc. for questions not answered in these manuals.

## Personal Protective Equipment (PPE)

Proper PPE must be worn during low risk or high risk operations to avoid injury. Low risk operations are defined as standard maintenance and diagnostics. High risk operations may refer to charging the system, opening pipes full of refrigerant, and similar operations.

For low risk operations, PPE includes safety glasses with side shields, long sleeve shirt or jacket, and safety shoes. For high risk operations, PPE requires additional face shield and protective insulated gloves (either leather or mechanics gloves).

All PPE must be made of thermally stable materials. Some examples of compliant materials include Nomex (or other aramids that meet optional fire resistance); Firewear (or other modacrylic/cotton blends that meet optional fire resistance); fire-resistant cotton that meets optional fire resistance; and cotton that meets base requirements.

# SAFETY

## Fire Safety

Fire detection, smoke detection, and fire suppression systems must be installed according to NFPA and local code requirements. Fire extinguishers should be located in easily accessible areas near the unit and be clearly marked. Exits must be clearly marked to enable easy evacuation in cases where the fire cannot safely be suppressed.

Keep the unit clean and free of scrap materials, oils, or solvents to prevent the possibility of fire.



### **DANGER!**

IN THE EVENT OF A FIRE, DE-ENERGIZE THE UNIT IMMEDIATELY BY DISCONNECTING THE POWER. ALWAYS DISCONNECT ALL POWER UPSTREAM OF THE UNIT AND SAFELY AWAY FROM THE FIRE BEFORE EXTINGUISHING A FIRE. THEN USE THE FIRE EXTINGUISHER. ATTEMPTING TO EXTINGUISH A FIRE IN A MACHINE CONNECTED TO ELECTRICAL POWER CAN RESULT IN SERIOUS INJURY OR DEATH.

## Refrigerant Safety

### **DANGEROUS PROPERTIES**

Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and hydrofluoroolefins (HFOs) are heavier than air and will replace air in a confined space, leading to a possible risk of suffocation if released into a work space. If a spill occurs, contractors must wear a self-contained breathing apparatus or evacuate the area until it has been properly ventilated.

Some refrigerants, such as CFCs and HCFCs, are non-toxic when mixed with air in normal conditions. However, when they come into contact with open flames or an electrical heating element, they decompose to form toxic elements, such as phosgene gas, which can cause suffocation when inhaled.

### **LEAK DETECTORS**

Leak detection systems analyze air samples to determine the concentration of a refrigerant in the air. These systems help limit the environmental impact, reduce running and service costs, and limit health and safety hazards. Leak detection systems are recommended for areas such as mechanical rooms, walk-in coolers and freezers, evaporator coils, and areas where people walk around piping or refrigeration components.

### **REFRIGERANT LINE SAFETY**

Refrigerant lines are pressurized. Before cutting refrigerant lines or opening and closing valves, make sure the refrigerant lines are properly isolated. Improperly isolated lines or allowing lines to absorb heat can cause lines to burst. It is important for a trained and experienced contractor to provide service to refrigerant lines.



### **DANGER!**

NEVER APPLY HEAT DIRECTLY TO A PIPE CONTAINING REFRIGERANT. RAPID THERMAL EXPANSION OF LIQUID REFRIGERANT CAN CAUSE THE PIPE TO BURST.

# INSTALLATION

## General

All systems must be installed according to national and local electrical codes. Failure to do so may result in equipment damage or personal injury.

The installing contractor is responsible for ensuring that any field-installed materials are compatible with the refrigerant, such as pipes, valves, fittings, gaskets, or other materials that come into contact with refrigerant.

## Receiving Inspection

All Zero Zone equipment has been thoroughly inspected at our factory, but the entire system should be thoroughly examined before unloading. Safe shipment is the responsibility of the carrier.

- Major components should be inspected for damage. Check whether any components came loose from the mounting position.
- Refrigerant lines and oil lines should be inspected for any breaks or leaks. This damage can be hidden if not carefully inspected.
- Controls can be damaged in transit and should be inspected.
- Electrical connections may loosen during shipment. The installing contractor must check all connections and tighten if necessary before energizing equipment.
- All braze and mechanical joints should be re-tested and tightened if necessary before evacuation and charging.

Rack systems are shipped with a holding charge of nitrogen. Confirm that the system has the appropriate pressure before cutting any lines or opening the system. In the unlikely event that a system arrives without pressure, the system must be checked for leaks before piping is installed. Contact the Zero Zone Service Department (800-708-3735) for the appropriate steps for repairs.

## Reporting Damage

Any damage must be properly documented on the Bill of Lading by the person receiving the shipment. Shipping damage is the responsibility of the carrier. Any damage should be recorded and a claim should be filed with the shipping company. Photographs of damaged equipment should be taken for documentation. The Zero Zone Service Department will assist in preparing and filing your claims, including arranging for an estimate and quotation on parts. However, filing the claim is the responsibility of the receiving party. Zero Zone must be notified in a timely manner.

## Ship Loose Components

Most systems will be sent with ship loose components that must be installed either prior to final placement of the system or at the time of system start-up. When the system is delivered, ensure that all items are accounted for by looking at the Ship Loose Bill of Materials. Contact the Zero Zone Service Department (800-708-3735) to replace lost or damaged components. Once ship loose components have been inspected, all ship loose components should be stored in a safe location to avoid misplacing them.

Ship loose ball valves and control valves are always identified per circuit. That information can be found on the circuit schedule that accompanies each system (See Figure 1 on page 7). The refrigeration contractor should be careful to verify that each part is installed on the intended circuit. Control valves are sized based on port size, not connection size. It is possible to have different valve sizes that look similar but may have different port sizes. Always refer to the manufacturer's recommended mounting positions and brazing techniques.



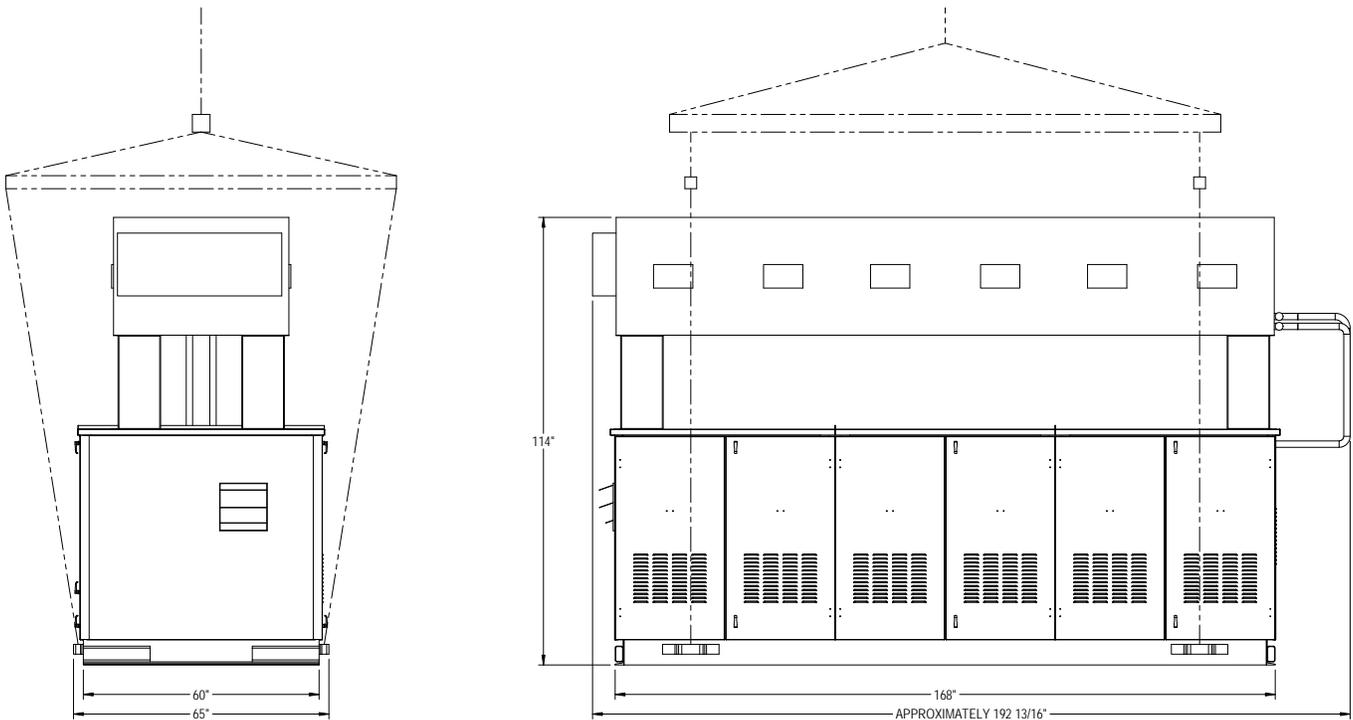
# INSTALLATION

## Rigging and Equipment Handling

The only parts of the system designed to carry the entire lifting load are the supplied lift points or base of the system. A lifting diagram is attached to the front of the system that indicates the appropriate lift points of that specific unit (See Figure 2).

FIGURE 2: Sample Lifting Diagram

*FAILURE TO USE ALL LIFTING POINTS WILL VOID WARRANTY*



Lift the system using spreader bars to prevent damage to the unit, electrical panels, and piping. All lifting points must be used to distribute the weight evenly to prevent the system from sagging during lifting. When lifting with a crane or hoist, lift slowly to ensure the system is balanced. Systems can be top or front heavy, especially if compressors are double stacked.

When using a forklift, the forks must be spread as wide as possible. Place the forks under the bottom base frame and extend through the base rails. Use fork extensions if the forks do not extend beyond the base frame. The system should be secured to the forklift and lifted slowly to ensure the system is balanced. For systems over 10' long, multiple forklifts must be used. Be careful to not damage system components with the forks and to not tip the system.

# INSTALLATION

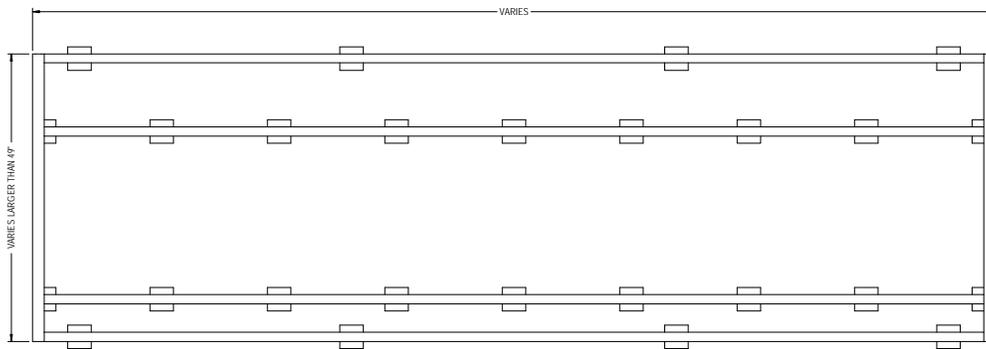
## Setting the System

Proper installation and placement of the system is important for overall performance and longevity of the system. Zero Zone systems must be placed on a rigid, non-warping mounting surface that can support the entire weight of the system, including the completed piping and operating weight of the refrigerant. This could be a solid, smooth, and level concrete foundation or a steel frame of adequate size and strength. The foundation should be designed to minimize vibrations and pulsations to reduce noise and structural fatigue. Always refer to local building codes.

### SERVICEABILITY AND MECHANICAL CLEARANCES

Serviceability is a primary concern when setting the system. Indoor systems typically require a minimum of 24" service clearance around the perimeter of the system. A clearance of 48" to 96" is required around the perimeter of air-cooled condensers. Outdoor systems require at least 48" of clearance around the entire perimeter. Always refer to local building codes.

FIGURE 3: Sample Recommended Isolation Pad Locations



### ISOLATION PADS

All systems are shipped with isolation pads or spring mounts. Isolation pads must be installed before any piping is installed. Each system includes diagrams specifying the location and layout of isolation pads (See Figure 3 and Figure 4).

Outdoor parallel systems (OPS) do not require isolation pads if the equipment support system has a floating concrete pad independent of the main building or building structure. If the OPS will be placed on steel structures connected to the roof of a building or on a concrete floor connected directly to the building, Zero Zone recommends using isolation pads.

### ISOLATION SPRINGS

Optional isolation springs must be installed with the top plate parallel to the main support channels before any piping is installed (See Figure 5). Use the adjustment bolt to make sure the upper and lower spring assemblies have a clearance of at least 1/4" to 1/2". The springs may need to be readjusted after the equipment is charged and completely functional. See manufacturer's spring instructions for further details.

FIGURE 4: Isolation Pad



FIGURE 5: Isolation Spring



# INSTALLATION

## Refrigeration Piping

### PIPING TYPE

All piping installed on the refrigeration equipment from the factory or installed in the field should meet the specified Zero Zone engineering requirements for material, diameter, and rated maximum working pressure. Piping must be installed in compliance with good piping practices. All piping and fittings shall be joined according to best piping practices so that the maximum working pressure of the pipe is not de-rated below the specified design working pressure.

### REFRIGERATION PIPING REQUIREMENTS

1. Design pressure greater than 700 psig: Mueller Streamline XHP 90 and XHP 120 (C19400 ASTM B465), Sch80 304 SS pipe (ASTM A316), or 304 SS tube (ASTM A269).
2. Design pressure less than 700 psig: Mueller 700 psig copper tube and fittings. This will be ACR copper Type K or L based on size (Type L up to 1 3/8", Type K greater than 1 3/8" OD).
3. Copper piping must be brazed using SILVERPHOS 15 (SP15) AWS A5.8 BCuP-5 or equivalent (15% Silver).
4. Stainless steel piping must be welded.
5. Mechanical joints such as flare and compression fittings should be avoided where possible.

### WATER AND GLYCOL PIPING REQUIREMENTS

1. ACR copper Type K, L, and M should be used unless otherwise specified. All joints shall be brazed or soldered.
2. Piping material other than copper may be used.

### REFRIGERANT LINE SUPPORTS

Before installing refrigeration lines, confirm load calculations to ensure piping supports will bear the entire weight of the refrigeration lines. The supports should be spaced so the line will not sag, which will minimize the possibility of refrigerant oil pooling in the vapor line. Refrigerant vapor lines should be pitched at least 1/2" per 10' in the direction of refrigerant flow. If clamps are needed, Zero Zone recommends using Hydra-Zorb style clamps or Klo-Shure insulation couplings. When hanging pipes, check specifications for pipe support (saddles).

### NITROGEN PURGING

Refrigerant lines must be purged with dry nitrogen to eliminate oxidation formation within the copper lines during brazing or welding. Suggested minimum flow rate is 2-3 cubic feet/hour (or 1.5-2.0 psig).

**It is critical to keep internal components and piping clean during installation.** Without nitrogen purging, the oxidation residue will eventually be swept off the pipe walls by the refrigerant or polyolester oil (POE oil), causing the refrigerant or oil to become dirty and discolored. This residue will also collect in the filters, thermostatic expansion valve screens, and other components, which may cause a loss of refrigeration.

# INSTALLATION

## SUCTION LINE SIZING

Suction lines must be sized correctly to avoid excessive pressure drop, which will cause poor system performance, higher energy costs, and possible system damage. The overall pressure drop in suction lines must be kept to a minimum, typically 2°F maximum change in saturation temperature. Length of runs, elbows, suction control valves, suction-line filters, and accumulators must be factored into the overall pressure drop. All branch connections should tee into the top of the main horizontal suction lines. Suction lines must be sized based on total equivalent length of run from the evaporator to the compressors with minimal use of 90° elbows (long radius only). For more information, see ASHRAE piping guidelines.

### Horizontal Suction Lines

Horizontal suction lines should be pitched in the direction of flow and sized to maintain 700 fpm at minimum capacity. All branch connections should tee into the top of the main horizontal suction lines to avoid oil draining from a main suction line to a branch line during an off cycle or shutdown of the branch circuit.

### Vertical Suction Risers

Vertical suction risers should be sized to maintain 1,250 fpm at minimum capacity. Vertical suction risers greater than 4' tall will require a P-trap at the base to facilitate oil return, and vertical suction risers greater than 20' will require another P-trap every 20'. Optional inverted trap at the top of the riser is recommended. If large capacity reductions within the system are expected, double risers should be considered. Double risers are sized so both lines equal the total cross sectional area of a single riser appropriately sized for the maximum load at design conditions.

To avoid excess oil accumulation, oil traps should be of minimum depth and the horizontal section should be as short as possible. Oil traps can be either preformed or configured with long radius 90° elbows and long radius 90° street elbows. Oil traps should always be the full pipe size as that of the main horizontal line.

## LIQUID LINE SIZING

Liquid lines must be sized so that a solid column of liquid is continuously delivered to the expansion valve with minimal pressure drop. If liquid line pressure drops below its saturation temperature (2°F or greater), the liquid will begin to flash off into vapor, which will cause poor system performance. Subcooling the liquid refrigerants is recommended to avoid the possibility of vapor flashing off at the expansion valve.

For systems with liquid-line solenoids, use velocities below 300 fpm to avoid the chance of hydraulic shock or liquid hammer from the cycling of the liquid-line solenoid. All liquid branch tee connections should be pulled from the bottom of the horizontal liquid lines or liquid loops to ensure a solid column of liquid is supplied to the expansion valve. Never pull liquid branch circuits from a vertical rise liquid line.

## DISCHARGE AND HEAT RECLAIM LINE SIZING

Discharge lines should be sized according to maximum pressure drop. Excessively high pressure drops will decrease compressor capacity. Pressure drop from compressor to condenser will typically be between 5-10 psig. Discharge lines should be pitched in the direction of flow. With the high pressure of vapor in discharge lines, oil flows more freely, so line sizing is less dependent on velocity. Velocities should be kept below 3,000 fpm to avoid excessive noise. Full-line oil traps are required at the base of all vertical risers to avoid excess oil accumulation.

Reclaim lines should be the same size as discharge lines. If a reclaim line is over 25' long, line sizes must be verified to minimize pressure drop.

## CONDENSER RETURN LINE SIZING

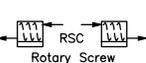
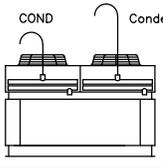
Condenser return lines (sometimes referred to as drop legs) should be sized and installed to allow free draining of the condenser. The velocity should not exceed 120 fpm. A larger return line incorporates a venting effect of the receiver. An alternative to the larger return line would be venting off the top of the receiver with a smaller line piped to the inlet of the full-time side of the condenser with a check valve installed at the condenser connection.

# INSTALLATION

## Common Piping Symbols

The following piping symbols are commonly used on Zero Zone refrigeration piping diagrams (See Figure 7).

FIGURE 7: Common Piping Symbols

DDPR  Discharge Differential Pressure Regulator	TXV  Thermostatic Expansion Valve	PC  Pressure Control (Switch)	VE  Vibration Eliminator	IPR  Inlet Pressure Regulator
SG  Sight Glass	REV  Relief Valve	LPC  Low Pressure Control (Switch)	HLBV  High to Low Bypass Valve	OAT  Outside Ambient Temp
ACC  Accumulator	DRV  Dual Relief Valve	HPC  High Pressure Control (Switch)	DM  Discharge Muffler	DTC  Discharge Temp Control Valve
RSC  Rotary Screw Compressor	DRVRD  Dual Relief Valve with Rupture Discs	DPC  Dual Pressure Control (Switch)	ROF  Replaceable Oil Filter	COMP  Compressor
BVSCH  Ball Valve w/Schraeder		MV  Metering Valve	LFD  Liquid Filter Drier	
QAV  Angle Valve	DV  Diaphragm Valve	EPR  Evaporator Pressure Regulator	SUCF  Suction Filter	ORF  Orifice
BV  Ball Valve	BFV  Butterfly Valve	3MBV  3-Way Motorized Ball Valve	EEPR  Electronic Evaporator Pressure Regulator	UNION  UNION
SOL  Solenoid	MBV  Motorized Ball Valve	CV  Check Valve	HRH2O  Hot Water Reclaim	LICT  Liquid Injection Cap Tube
OPR  Outlet Pressure Regulator	SCV  Split Condenser Valve	RL  Rotolock	HRAIR  Air Heat Reclaim	COND  Condenser
CP  Charging Port	HRV  Heat Reclaim Valve	OR  Oil Reservoir	REC  Receiver	
TVLV  T-Valve	LDPR  Liquid Differential Pressure Regulator	OS  Oil Separator	MSBCL  Mechanical Subcooler	ACCOND  Air Cooled Condenser
TS  Temperature Sensor (Low Range)	TS  Temperature Sensor (High Range)	OILF  Oil Filter	FSW  Flow Switch	EVAP  Evaporator
PXD  Pressure Transducer	STR  Strainer	SS-EPR  Suction Stop Evaporator Pressure Regulator	NAD  Nozzle Adapter	
PT  Pressure Tap	DTC  DTC Valve			
PUMP  Pump				

# INSTALLATION

## Condenser Installation

**Note: Condensers must be thoroughly inspected when delivered. Any shipping damage or loss of equipment must be reported to the carrier. Photographs of damage must be taken.**

Always follow the manufacturer's recommendations when handling and lifting a condenser. The placement of a condenser is very important. Condensers should always be mounted higher than the receiver to facilitate proper liquid draining from the condenser. The condenser foundation or structure must be level and robust to handle the entire operational weight and physical size of the condenser. All legs must be installed to rest on the foundation or structure; manufacturers will not allow any legs to float in the air beyond the foundation or structure. Condensers must be securely fastened to the foundation or structure.

Condensers should not be placed near obstructions that may impede condenser air flow. This includes fences, walls, any structures positioned close to the condenser, and inside a pit. If this is necessary, the manufacturer's recommendations must be followed precisely. Failure to follow recommended condenser placement could result in poor system performance and high condensing temperature.

There must be a clearance of at least 4' around the condenser to any wall or obstruction. If multiple condensers are placed parallel to each other, clearance of at least 8' is required between condensers to allow for proper air circulation. Refer to national and local codes to determine minimum electrical clearance needed in front of the electrical enclosure. Check the voltage rating on the condenser's nameplate and confirm that the job site can supply that voltage.

Condenser headers are not designed to hold additional weight. All field connections must be adequately supported and clamped near the headers. Improper support could damage copper tubing within the condenser.

## WATER QUALITY

For water-cooled condensing units, the installing contractor and equipment owner are responsible for water purity. The water should be tested by an independent laboratory to confirm that the water meets or exceeds all government regulations. Condensers can be damaged if the water has high levels of corrosive chemicals, and this damage is not covered by the manufacturer's warranty.

## Evaporator Installation

**Note: Evaporators must be thoroughly inspected when delivered. Any shipping damage or loss of equipment must be reported to the carrier. Photographs of damage must be taken.**

Check the voltage rating on the evaporator's nameplate and confirm that the job site can supply that voltage.

Always follow the manufacturer's recommendations when handling and lifting evaporators. Evaporators must be hung from a solid, level structure. When lifting the evaporator, be careful to avoid flattening the drain pan. The minimum rear clearance should equal the overall height of the evaporator. Confirm that the room, product, or other peripheral objects will not obstruct the airflow of the evaporator. Allow 24" on either end of the evaporator for service access. For more detailed installation information, refer to the manufacturer's recommendations.

When connecting refrigerant lines, provide an adequate length of horizontal suction line to mount the thermostatic expansion valve bulb. The bulb must be clamped securely at the 4 or 8 o'clock position for proper installation.

# ELECTRICAL INSTALLATION

## Electrical Requirements

**⚠ CAUTION!** DUE TO THE INHERENT DANGERS WITH ELECTRICITY, ONLY QUALIFIED ELECTRICAL CONTRACTORS SHOULD SERVICE SYSTEMS.

*Note: Electrical connections may loosen during shipment. The contractor must check and tighten electrical connections, if necessary.*

### ELECTRICAL EQUIPMENT DATA

For specific system data, always refer to the main label, located on the electrical enclosure near the main electrical feed (See Figure 8).

Zero Zone systems main voltage typically operates between 460V-480V, 230V-240V, or 208V. Systems must operate within 10% of the rated voltage, as referenced on the main label.

FIGURE 8: Sample Main Label

		Model Number:	R-S0402S2-5-449A
Ramsey, MN		Serial Number:	ABC111050-0617
<b>Power Feed 1 Requirements</b>	<b>Main Power</b>		
<b>Voltage:</b>		208-230/3/60	V/Ph/Hz
<b>Minimum Circuit Ampacity:</b>		80	Amps
<b>Maximum Overcurrent Protection Device:</b>		100	Amps
<b>Maximum SCCR:</b>		10K	Amps
<b>Control Circuit Power Requirements</b>			
<b>Voltage:</b>		110-120/1/60	V/Ph/Hz
<b>Source:</b>		Separate Source	
<b>Minimum Circuit Ampacity:</b>		12	Amps
<b>Maximum Overcurrent Protection Device:</b>		15	Amps
<b>Design Pressures</b>	<b>Refrigerant</b>	R449A	
	<b>High Side:</b>	450	PSI
	<b>Low Side:</b>	180	PSI
<b>Condenser Minimum Marked Design Pressure:</b>		450	PSI
<b>Receiver Capacity @ 80%</b>		170	LBS
<b>Compressors</b>			
<u>Model</u>	<u>RLA</u>	<u>LRA</u>	<u>Power Feed</u>
4EES-4-2DU-1D	22.2	142	1
2KES-05-2DU-0D	5.4	32	1
2JES-07-2DU-0D	6.7	40	1
2HES-1-2DU-0D	7.2	42	1
<b>Condenser</b>			
<u>Model</u>	<u>FLA</u>		<u>Power Feed</u>
Recold JC-120	29		1
Pump	4		1

Forced Oil Cooling System: U.S. Patent 6,145,326  
 Type 1 Enclosure  
 Industrial Control Panel for Refrigeration Equipment - Conforms to STD UL508A  
 ETL LISTED - Conforms to ANSI/UL STD 1995  
 Certified to CAN/CSA STD C22.2 NO. 236  
 ETL LISTED - Conforms to NEC ANSI/NFPA No. 70-2008



# ELECTRICAL INSTALLATION

## Field Wiring

**Note:** Always follow the National Electrical Code (NEC) and local codes for field wiring. All field wiring should be completed by an experienced, licensed contractor.

### MAIN POWER

Minimum circuit ampacity (MCA) and maximum over-current protection device (MOPD) are listed on the main label (See Figure 8 on page 14). The size of field-supplied MOPD must not exceed the listed value.

Main power conductors must be sized based on the MOPD. The electrical contractor is responsible for proper sizing of all conductors. Always follow NEC and local codes when sizing main power conductors.

Ground conductors must be sized based on the MOPD. The electrical contractor is responsible for proper grounding. Always follow NEC and local codes when sizing ground conductors.

### CONTROL POWER

#### Single Point Power

Typically, main power voltage and control power voltage are the same. In that case, only one power feed is required. If single point power is provided, a separate control power connection is typically not required. A control power transformer may be incorporated for single point power when main power voltage and control power voltage are different.

#### Multiple Point Power

For main power voltage or control power voltage, there may be multiple feeds based on multiple voltage requirements. If requested, a control power transformer can replace the need for a separate feed for control power. See main label for control power requirements.

### SENSOR INPUT WIRING

All field-wired inputs to system controllers should be wired with shielded cable to protect controller from noise associated with induced voltage. Always avoid running sensor wires past lighting ballasts, motors, and other electrical devices. Field-wired sensors are indicated on the system input/output schedule (I/O schedule) and should be connected directly to appropriate board points.

### OTHER FIELD CONNECTIONS

Several field connections may be required for proper system operation. Field wiring is shown with dashed lines on electrical diagrams. All electrical diagrams should be examined thoroughly to ensure that all required connections are completed.

### TERMINAL BLOCK NUMBERING

Terminal blocks in all control panels are numbered with the same designation as wires connected to the terminal (See Figure 9).

### AUXILIARY EQUIPMENT

Only equipment represented by the main label and circuit schedule should be connected to the Zero Zone system.

FIGURE 9: Terminal Block



# ELECTRICAL INSTALLATION

## SENSORS

All temperature sensors provided by Zero Zone must be connected to the Zero Zone system. If any other temperature sensors are used, they must be approved by Zero Zone.

Zero Zone is only responsible for leak detectors and temperature sensors provided by Zero Zone.

## COMMUNICATIONS

Zero Zone recommends remote communications whenever possible. The contractor and customer are responsible for connecting the Zero Zone system to the customer network.

When communication devices are installed by the factory, the refrigeration contractor should confirm operation of those devices. If any other communication devices are used, they must be approved by Zero Zone.

## VARIABLE FREQUENCY DRIVES (VFD)

Field wiring for VFDs must use shielded VFD-rated cable or dedicated conduit for power wiring only. Field-mounted VFDs must be mounted with proper clearances per the recommendations from the manufacturer. Installation must comply with the NEC and local codes.

## Electrical Safety



### **WARNING!**

DISCONNECT POWER SUPPLY BY FOLLOWING YOUR COMPANY'S LOCK-OUT/TAG-OUT PROCEDURE BEFORE CONNECTING OR DISCONNECTING ELECTRICAL WIRES OR PERFORMING ANY WORK THAT MAY CREATE A RISK OF ELECTRICAL SHOCK. MORE THAN ONE DISCONNECT MAY SUPPLY POWER TO A CONTROL. UNDERSTAND THE LOCATION OF DISCONNECTS AND CIRCUIT BREAKERS. CHECK WHETHER CIRCUITS ARE ENERGIZED BEFORE OPENING PANELS.

## ELECTRICAL CLEARANCES

Refer to Zero Zone documentation and drawings to determine electrical clearances. Typically allow at least 4 feet in front of the electrical enclosures. Always follow the NEC and local codes.

## LOCK-OUT/TAG-OUT PROCEDURE

Zero Zone recommends following a lock-out/tag-out procedure that meets your company's requirements and OSHA regulations.

## ALARM SYSTEM

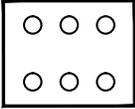
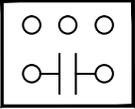
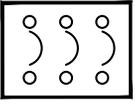
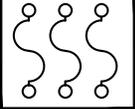
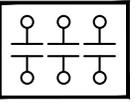
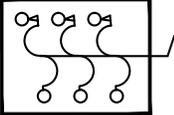
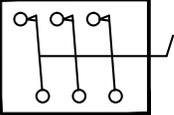
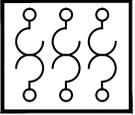
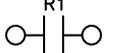
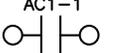
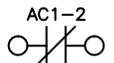
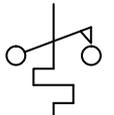
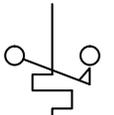
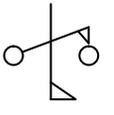
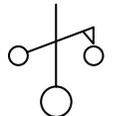
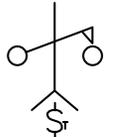
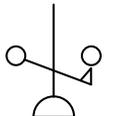
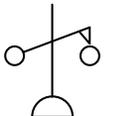
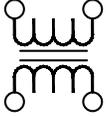
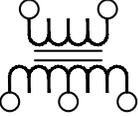
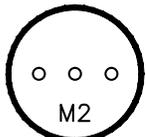
Systems are provided with alarms for temperature, pressure, and operational equipment. The refrigeration contractor should test the functionality of all alarms.

# ELECTRICAL INSTALLATION

## Common Electrical Symbols

Electrical symbols commonly used on Zero Zone refrigeration electrical diagrams (See Figure 10).

FIGURE 10: Common Electrical Symbols

				
Power Distribution Block	Power Phase Monitor	Circuit Breaker	Fuse Block	Contactor
				
Disconnect (Fusible)	Disconnect (Non-Fusible)	Motor Overload	Contactor Coil	Relay Coil
				
Time Delay Relay Coil	Relay Contact (Normally Closed)	Relay Contact (Normally Open)	Time Delay Relay Contact	Auxiliary Contact (Normally Open)
				
Auxiliary Contact (Normally Closed)	Switch	Temperature Switch (Close On Drop)	Temperature Switch (Close On Rise)	Flow Switch
				
Level Switch (Close On Drop)	Timed Switch	Pressure Switch (Close On Rise)	Pressure Switch (Close On Drop)	Pilot Light (Door Panel)
				
Pilot Light (Door and Solenoid Coil)	Pilot Light (Solenoid Coil)	Solenoid Coil	Panel Terminals	Electric Heater
				
Ground Lug	Fuse	Transformer	Transformer (Center Tap)	Motor

# PRE-START-UP

## Power Inspection

### MAIN POWER

- Identify main voltage and control circuit voltage on the main label .
- Measure each leg of the main power supply voltage at the main power source. Voltage must be within +/-10%. If the measured voltage on any leg is not within the specified range, notify Zero Zone and correct before operating the unit. Voltage imbalance must not exceed 2.0%. Excessive voltage imbalance between the phases of a 3-phase system can cause motors to overheat and eventually fail. Voltage imbalance can be calculated using the formula (See Figure 11).
- Measure and verify main voltage phase loss. Monitor and calibrate. Set to measured voltage, trip delay to 0, reset delay to 180 seconds, and unbalanced load to 2%.
- If a phase monitor light is not green after power is applied, then two phases must be swapped.
- Check 3-phase rotation of condensers and evaporators. Do not energize without verifying safe operation. Shafted motors with fan blades should be energized momentarily to confirm fan motor rotation.
- The unit requires the main power to remain connected during off-hours to energize the compressor's crankcase heater. The crankcase heater should remain on when the compressor is off to ensure liquid refrigerant does not accumulate in the compressor crankcase. Disconnect main power only during system service.

### CONTROL POWER

- Identify control circuit voltage on the main label.
- Measure and verify control voltage supply to the system.
- Check control amperage after start-up.

### UNINTERRUPTED POWER SUPPLY (UPS)

An uninterrupt power supply (UPS) is a backup power supply for the system controller. **Only use it as a backup power supply. Do not use it as a surge protector.** The UPS must be powered and allowed sufficient charging time, according to the manufacturer's recommendations.

### CONTROLLERS

A wide variety of controllers are used in Zero Zone systems. For specific operating instructions, please refer to the controller manufacturer's manual. Only an experienced contractor should install, start-up, or maintain controllers.

- Verify that the program is installed in the controller and confirm that all boards are online. Test the operations of the program before starting the system.
- Field wire the network between controllers, if needed.
- Connect all field-wired sensors before starting the system.
- Review the system input/output schedule (I/O schedule) to confirm field wiring inputs and outputs are connected properly. Test and calibrate all inputs and outputs.
- Verify that transducers are installed. Install if necessary.

FIGURE 11: Voltage Imbalance Formula

#### Voltage Imbalance Formula:

$$\text{Percentage of Imbalance} = \frac{(V_{avg} - V_x) \times 100}{V_{avg}}$$

- $V_{avg}$  = average voltage =  $(V1 + V2 + V3) / 3$
- $V_x$  = phase with greatest difference from  $V_{avg}$
- Voltage imbalance must not exceed 2.0%.

#### Example:

- Three voltages are measured:  $V1 = 442$ ;  $V2 = 454$ ;  $V3 = 460$ .
- The average ( $V_{avg}$ ) would be 452.
- The greatest difference from average ( $V_x$ ) would be  $V1 = 442$ .

$$\text{Percentage of Imbalance} = \frac{(452 - 442) \times 100}{452} = 2.2\% \text{ Imbalance}$$

- This exceeds the maximum allowable voltage imbalance of 2.0%

# PRE-START-UP

## Pressure Transducers & Temperature Sensors

Different controllers receive specific pressure transducers and temperature sensors. Refer to the manufacturer's manual for more information. Pressure transducers are shipped loose and must be installed in the field. Pressure transducers must be mounted vertically (wires up) so oil will not get trapped inside the transducer (See Figure 12). Temperature sensors are mounted at the factory (See Figure 13).

- Confirm controller setup by referring to the input/output (I/O) schedule.
- Follow the I/O schedule for wiring termination.
- Confirm controller reads proper pressure transducer and temperature sensor.
- Confirm pressure rating of transducer.
- Confirm accuracy of pressure transducer. Adjust in controller. Replace transducer if pressure is incorrect by more than 10 psig.
- Confirm calibration of all temperature sensors. Adjust in controller. Replace sensors if temperature is incorrect by more than 2°F.

*Note: High voltage wiring must be kept separate from low voltage sensor wiring.*

## System

**⚠ WARNING!** DO NOT START ANY COMPRESSORS UNTIL LEAK TESTING AND EVACUATION OF THE SYSTEM HAVE BEEN COMPLETED. LEAK TESTING AND PROPER EVACUATION ARE VITAL FOR SUCCESSFUL START-UP.

CONFIRM THAT MAIN POWER AND CONTROL POWER ARE SHUT OFF AT THE MAIN POWER DISTRIBUTION PANEL. ALL COMPRESSOR BREAKERS AND SWITCHES MUST BE OFF. THE COMPRESSOR CAN BE SERIOUSLY DAMAGED FROM PREMATURE OPERATION. FOLLOW YOUR COMPANY'S LOCK-OUT/TAG-OUT PROCEDURE.

## BEFORE LEAK & PRESSURE TESTING

Before leak and pressure testing, verify the following:

- The refrigeration system must be set and anchored securely in place.
- All system components must be installed, including evaporators, condensers, auxiliary heat exchangers, valves, and sensors.
- Field piping must be installed, properly supported, and all joints connected according to code.
- All isolation and ball valves must be opened to the system.
- For solenoids with manual opening stems, turn the stem to lift the solenoid disc off of the valve seat. Energizing the solenoid circuits will also assist in the leak testing and evacuation, but only the solenoids can be powered. Do not turn on the compressor.
- The equipment for testing pressure and evacuating the system must be in good repair and have been calibrated recently.

FIGURE 12: Pressure Transducer



FIGURE 13: Temperature Sensor



# PRE-START-UP

## LEAK & PRESSURE TESTING

The unit is pressure tested in the factory prior to shipping, but it must be checked after installing field piping to ensure a tight and leak-free system. Make sure to account for ambient temperature change, which affects system pressure.

1. Open all isolation valves, including solenoid valves.
2. Remove or isolate main relief valves to prevent them from opening. If main relief valve cannot be removed or isolated, the system should be pressure tested at less than 90% of the relief valve setting.
3. Use nitrogen to pressure test the entire system. Pressurize the system to the low side design pressure. The system should remain pressurized for at least 24 hours (or per local codes).
4. Check system pressure in multiple places to confirm that the entire system is equalized.

Any loss of pressure must be thoroughly investigated and the leak repaired. After the leak test is passed, the system should be reset to atmospheric pressure.

## SYSTEM EVACUATION

### Evacuation Set-Up

After the system is confirmed to be leak free, evacuation can begin. Do not install liquid filter driers at this time. All compressor suction filters and replaceable oil filters have been factory-installed prior to shipment.

1. Confirm all isolation and service valves are open.
2. Use a high-quality vacuum pump containing fresh, clean oil.
3. Use copper tubing between system connections and vacuum pump[s] instead of the typical manifold gauge hoses.
4. Continuously monitor the oil level and oil quality in the vacuum pump[s].

### Evacuation Procedure

After proper set-up has been completed, proceed with the evacuation procedure. During the third evacuation, polyolester oil (POE oil) should also be charged into the system. It is easier to charge POE oil while the system pressure is low because most oil charging pumps can charge against low pressure.

1. First evacuation: Pull down to 1,500 microns, and then break with dry nitrogen.
2. Second evacuation: Pull down to 1,000 microns, and then break with dry nitrogen.
3. Before the third evacuation, install liquid-line driers.
4. Third evacuation: Pull down to 500 microns, then add POE oil (**See "Charging POE Oil" on page 21**). Pressure will probably rise after adding POE oil. Pull system back down to 500 microns.
5. Isolate the system from the vacuum pump, then turn the vacuum pump off. Allow the system to stand at 500 microns for 30 minutes. If pressure does not rise, the system is tight and leak free. **Local codes may require that the final evacuation be confirmed by a mechanical inspector.**
6. If pressure rises, there may be moisture or a leak in the system. If there is moisture, continued evacuation is required. If there is a leak, it must be repaired.

# PRE-START-UP

## CHARGING PROCEDURE

**Note: All parties working with refrigerants and POE oil must follow EPA procedures. Following these procedures, using appropriate equipment, and having sufficient knowledge of refrigerants will reduce accidents and injuries. Refer to EPA and ASHRAE safety codes for more information.**

### Charging POE Oil

Polyolester oil (POE oil) should be added to the system during the third and final evacuation (see "**Evacuation Procedure**" on page 20). Use only the POE oil recommended by the compressor manufacturer. If oil is purchased through Zero Zone, the proper oil type will be shipped loose with the system. The contractor is responsible for supplying additional oil needed for operation. **Mixing different types of POE oils is strictly prohibited.**

1. Only use POE oil contained in a sealed and closed container. POE oil is very hygroscopic and will absorb water vapor quickly. Limit how long the oil is exposed to open air.
2. During the third system evacuation, pump clean and dry refrigerant oil into the compressor crankcases, oil separator, and oil reservoir separator (or combination separator reservoir). Oil can be pumped directly into each compressor crankcase or into the oil reservoir, which will then fill the compressor crankcase. Scroll compressors are typically shipped with a factory oil charge in the crankcase; check whether additional oil is needed.
3. Oil must also be pumped into the separator. See separator manufacturer's manual for recommendation on proper oil charge.
4. The initial oil charge should fill the compressors to 1/2 sight glass level and between 1/2 and 3/4 reservoir level. The oil level in the reservoir will drop as oil lines and filters fill and oil circulates in the system. The level should stabilize as the temperature of connected loads become stable.

### Charging Refrigerant

**Note: Before charging refrigerant into the system, the system must be evacuated and the receiver liquid-level probe or analog float must be calibrated to 0% (See "Evacuation Procedure" on page 20) or (See "Receiver" on page 22).**

1. Only use virgin refrigerant for charging the unit. The type of refrigerant will be listed on the main label for each system.
2. Connect a bottle of refrigerant to the charge manifold and connect the charging hose to the charging port located on the receiver.
3. While the unit is under a vacuum, break the vacuum with refrigerant until the system pressure rises above atmospheric pressure.
4. Continue to charge the receiver with liquid until the system is equalized and will not accept more refrigerant.
5. As the refrigerant bottle cools, pressure in the bottle will drop until no refrigerant can be charged into the system. As much as 25% of the contents may remain in the bottle. Further charging will require the unit to be started, at which time the unit must be charged with liquid between the receiver outlet isolation valve and the filter driers.

The specific amount of refrigerant charge is different for each model and is highly dependent on field-installed piping and auxiliary equipment. Actual system charge must be verified after the system is running, all circuits are operating/functioning, and system has stabilized.

**Note: If it is impossible to charge liquid refrigerant into the liquid line, then it may be possible to charge only vapor refrigerant into the suction line to complete the charging process. No liquid refrigerant may be added to the suction line. Charging vapor refrigerant into the suction line is not recommended and could void warranty. Contact the compressor manufacturer first.**



**WARNING!** CHARGING LIQUID REFRIGERANT INTO THE SUCTION LINE IS PROHIBITED AND MAY RESULT IN DAMAGE TO THE COMPRESSOR.

# SYSTEM START-UP

## General

**Note: Refrigeration system start-up should only be completed by a trained, experienced refrigeration contractor. The refrigeration contractor must make final adjustments for all components. For more information, please refer to the "Glossary" on page 35 or contact the Zero Zone Service Department (800-708-3735).**

## Condensers

- Confirm voltage at condenser with a voltage meter. The voltage should match the condenser manufacturer's nameplate voltage.
- Confirm proper fan rotation.
- Confirm condenser fan sequence of operation per control logic. Fan #1 (typically left side/full time when facing header) runs continuously with at least 1 compressor on and cycles off at minimum head-pressure set point.
- Confirm split valve shifts between full and split operations.
- The pump-out solenoid is controlled by suction superheat and compressor proofs. Confirm the pump-out solenoid de-energizes during low superheat condition and when all compressors are cycled off manually or by system failure.
- If the system has ECM fan motors, refer to the manufacturer's manual for details.

## VARIABLE FREQUENCY DRIVES (VFD)

Condensers installed with variable frequency drives will be shipped with VFD instructions and a manufacturer's manual. VFDs will be shipped with Zero Zone default parameters, which can be found in the Zero Zone documentation. For more information about the VFD, please use the supplied instructions or the manufacturer's manual.

## Receiver

All receivers contain a pressure relief valve and a 3-way manifold valve, which must be either front seated or back seated. The pressure relief valve must be piped to the outdoor air of the mechanical room or the exterior of the outdoor unit. The pressure relief valve setting must be equal to or less than the pressure rating of the receiver. See receiver nameplate for pressure rating.

Horizontal receivers use either a liquid-level probe (see below) or an analog float (no set up necessary). Vertical receivers will utilize a probe. In large horizontal receivers, the probe may be installed into a liquid-level column. Receivers may also be equipped with a liquid-level switch.

## SET UP FOR RECEIVER LIQUID-LEVEL PROBE

Receiver liquid-level probe is used as a low/high alarm indicator. Refer to the manufacturer's manual for more information. Before adding refrigerant to the receiver, confirm liquid-level probe reads 0%. Follow these calibration instructions for 0-5V calibration. (1-6V calibration will produce similar results, but the values will be incrementally different.)

- Liquid-level probes are calibrated at the manufacturer's factory. If the probe is not calibrated correctly or the refrigerant does not match the refrigerant specified on the probe, recalibration will be necessary.
- 12V power is supplied to the probe.
- To check the voltage output of the probe, use the access cover in the probe's head. A voltage meter should be installed in parallel with the signal and common terminals.
- Disconnect the signal from the controller and measure the output across the signal and common terminals.
- With no refrigerant in the receiver, the voltage meter should read 0.00-0.05V. If not, adjust the Z (zero) calibration screw until the proper voltage is reached.
- Add or raise the refrigerant level in the receiver to 50%.
- Recheck with a voltage meter. It should read 2.5V. If not, adjust the S (span) calibration screw until the proper voltage is reached.

# SYSTEM START-UP

## SET UP FOR RECEIVER LIQUID-LEVEL ANALOG FLOAT

Horizontal receivers can use an analog float, which requires no set up by the refrigeration contractor. The refrigeration contractor should verify that the voltage is correct and that the float works properly.

## Compressors

Zero Zone systems may use reciprocating, scroll, or screw compressors (see the "**Glossary**" on page 35). Since each compressor is different, the following instructions are only general. Refer to the compressor manufacturer's manual for specific instructions.

- Ensure all electrical connections to compressor are tight.
- Ensure all individual compressor power/door switches are off.
- Ensure all compressor breaker/disconnects are off, located in electrical enclosure.

Switch compressor power on to continue with next steps.

- Ensure main power is correct at power distribution block (PDB).
- Ensure voltage is correct at line side of compressor breaker/disconnect.
- With refrigerant in the system, turn on each compressor individually and check voltage, amp draw, and rotation (if applicable).  
**Note: Reciprocating compressors can rotate in either direction, so it is not necessary to check them for proper rotation.**
- For screw compressors: Install suction and discharge gauges. Confirm proper oil level at oil separator. Confirm rotation by using gauges. The compressor suction service valve should be closed completely and then opened two turns. Manually bump the compressor on for a couple of seconds. A sudden drop in the suction pressure gauge indicates that the compressor is rotating in the correct direction.

## OIL FAIL CONTROLS

Zero Zone systems are equipped with oil fail controls. Because controls vary depending on the manufacturer, controls must be confirmed for proper testing per the manufacturer. All oil fail controls must be tested to ensure that the compressor will be protected. When the oil fail control trips, an alarm will be generated.

## OIL SEPARATORS

The oil separator, located in the discharge line, separates oil droplets from discharge gas. Zero Zone uses several types of oil separators, including coalescent, centrifugal, and impingement. All separators must be primed with oil.

Most separators are serviceable and contain a float on the bottom. If there is no oil flowing through the float, the float must be removed and cleaned or replaced.

Coalescent oil separators contain a filter that must be checked or replaced after approximately 1 week of runtime. Pressure differential indicator should be monitored for excessive pressure drop across the filter. The indicator will alarm when the pressure drop exceeds 12 psig.

## OIL RESERVOIRS

Oil is stored in either an external oil reservoir or an integral reservoir on an oil separator. The pressure in an external oil reservoir should be confirmed with the pressure rating of the oil vent check valve. The external oil reservoir is vented to the warmest suction group on the system.

## OIL FILTERS

The oil filter can be located in either the oil-inlet line or the oil-outlet line of the oil reservoir. A spare filter will be supplied with the system, and it should be changed after the system is at full capacity and stabilized (or sooner due to excessive pressure drop).

# SYSTEM START-UP

## OIL LEVEL REGULATORS

Oil is fed from the reservoir to individual regulators on the compressors. Compressors will use either mechanical floats or electronic regulators to maintain crankcase oil levels according to compressor manufacturer's specifications.

- Reciprocating compressors can use either mechanical floats or electronic regulators.
- Scroll compressors will use electronic regulators. Scroll compressors do not have positive displacement oil pumps, so low oil level lockout is provided in the oil level regulator.
- Screw compressors do not require oil level regulators.

### Mechanical Oil Float

Mechanical floats can be used in reciprocating compressors. Adjust oil level according to compressor manufacturer's specifications.

### Electronic Oil Regulators

Electronic regulators can be used in reciprocating compressors or scroll compressors. Electronic regulators inject oil through an integrated solenoid into the compressor crankcase to maintain a level of 1/2 sight glass. This can be done in a high-pressure or low-pressure oil system.

## OIL PRESSURE REGULATORS

When applicable with mechanical oil regulators, the outlet pressure regulator (OPR), located in the oil header, should be set for approximately 30 psig above the warmest saturated suction temperature (SST) for the group of compressors it is serving. This OPR helps prevent excessive oil foaming in the mechanical oil regulator by reducing the oil supply pressure.

## PRESSURE CONTROLS

Set pressure controls according to the compressor manufacturer's specifications. Confirm that the compressor shuts off and turns on at the desired set pressures.

### Setting Low-Pressure Control

1. Install manifold gauge set.
2. Slowly front seat suction service valve until compressor stops. Then slowly open suction service valve until compressor cuts in. Repeat until control is set to desired cut-in pressure.
3. Slowly close suction service valve to determine cut-out pressure. Repeat until control is set to desired cut-out pressure.
4. Do not allow the compressor suction pressure to drop below 0 psig. Running a compressor in vacuum can damage the compressor..

### Setting High-Pressure Control

1. Install manifold gauge set.
2. Slowly front seat discharge service valve until compressor cuts out. Then slowly open discharge service valve until compressor cuts in. Repeat until control is set to desired cut-out pressure.

 **WARNING!** DO NOT EXCEED 90% OF HIGH-SIDE RELIEF VALVE DESIGN PRESSURE.

## LIQUID INJECTION

Low temperature compressors using high-glide refrigerants require some form of liquid injection. Refer to the manufacturer's manual for operation and testing of controls.

# SYSTEM START-UP

## Evaporators

- Confirm voltage at evaporator with a voltage meter. The voltage should match the evaporator manufacturer's nameplate voltage.
- Confirm fan rotation for all fans on 3-phase units. Make sure all fans are working and are not obstructed.

## Expansion Valves

In all systems, either a thermostatic expansion valve (TEV or TXV) or an electronic expansion valve (EEV) will be connected to an evaporator. Proper superheat adjustment is important for evaporator efficiency and to provide cool return gas temperatures for the compressors.

### THERMOSTATIC EXPANSION VALVE (TEV)

TEVs—also known as TXVs—require superheat adjustments after the system has operated and stabilized. Adjustments must be completed by a qualified refrigeration contractor. Contractors must use a high-quality temperature meter and manifold gauges. The temperature probes must be connected to the clamp that holds the expansion valve bulb, and manifold gauges must be connected to the suction line as close to the evaporator bulb as possible.

### ELECTRONIC EXPANSION VALVE (EEV)

EEVs require superheat adjustment after systems have operated and stabilized. Adjustments must be completed by a qualified refrigeration contractor. Adjustments must be made through the electronic controller. See the controller manufacturer's manual for how to adjust superheat. Temperature meter and manifold gauges should be used to confirm actual superheat settings.

*Note: All EEVs must close at least once per day to maintain calibration.*

### SUPERHEAT SETTING

Typical superheat settings are 6-8°F. Refer to the manufacturer's recommendations for superheat settings.

*Note: A minimum of 20°F superheat and a maximum of 40°F superheat is allowed at all compressor suction service valves.*

## Defrost

Each circuit on the rack has a defrost schedule that starts and stops defrost for that circuit. Typically, a circuit off-auto control switch and light are provided, and an initial defrost program will be set in the circuit control. Defrost operation must be confirmed and adjusted by a refrigeration contractor. Defrost duration must be monitored to confirm all ice has been removed from the coil and drip pan before refrigeration begins.

Defrost termination is recommended for electrical and gas defrost evaporators. See manufacturer's recommended termination set point.

### ELECTRICAL DEFROST

Confirm that voltage and amperage on the nameplate matches the circuit schedule. Defrost breaker is sized to about 125% of the defrost load. Confirm that the amp draw does not exceed 80% of breaker size.

After initiating defrost, confirm suction and liquid solenoid valves will close during the defrost cycle. The frequency and duration of the defrost time should follow the manufacturer's recommendation.

### OFF-CYCLE DEFROST

After initiating defrost, confirm suction and liquid solenoid valves will close during the defrost cycle. The frequency and duration of the defrost time should follow the manufacturer's recommendation.

# SYSTEM START-UP

## HOT GAS DEFROST

After initiating defrost, confirm suction and liquid solenoid valves (if applicable) close during the defrost cycle and that the hot gas solenoid valve opens simultaneously. Hot gas from the discharge line is used to defrost cases by reversing the flow through the evaporator coil. To reverse flow, a hot gas header must be installed parallel to the suction and liquid header.

An electronically operated DDPV valve (in the discharge line) directs system pressure to where the system is in defrost. The system pressure forces hot gas through the suction line, where it condenses into liquid in the frost-laden evaporator coil. Movement of the condensed hot gas/liquid mixture into the liquid header is induced by creating a pressure drop across the DDPV that must be field-adjusted to 25-35 psig (with no circuits in defrost) between the hot gas header and the liquid header. When defrost is terminated, the DDPV valve energizes the solenoid to open the valve, allowing normal system operation to resume.

The frequency and duration of the defrost time should follow the manufacturer's recommendation. Gas defrost may include a 5-10 minute drip time to allow condensation to drip off the evaporator coil and clear the drain pan.

### Discrete Header

At the optional discrete header, hot gas from the evaporator returns to the discharge line downstream side of the DDPV valve. This prevents any non-condensed liquid from mixing with quality liquid feeding the evaporators.

## LATENT RECEIVER GAS DEFROST

After initiating defrost, confirm suction and liquid solenoid valves (if applicable) close during the defrost cycle and that the gas defrost solenoid valve opens simultaneously. Latent receiver gas is used to defrost cases by reversing the flow through the evaporator coil. To reverse flow, a gas defrost header must be installed parallel to the suction and liquid header.

An electronically operated LDPR valve (in the liquid line) directs system pressure to where the system is in defrost. The system pressure forces latent receiver gas through the suction line, where it condenses into liquid in the frost-laden evaporator coil. Movement of the condensed gas/liquid mixture into the liquid header is induced by creating a pressure drop across the LDPR that must be field-adjusted to 25-35 psig (with no circuits in defrost) between the gas defrost header and the liquid header. When defrost is terminated, the LDPR valve energizes the solenoid to open the valve, allowing normal system operation to resume.

The frequency and duration of the defrost time should follow the manufacturer's recommendation. Gas defrost may include a 5-10 minute drip time to allow condensation to drip off the evaporator coil and clear the drain pan.

## Refrigeration Circuits

Each system will have multiple types of mechanical and/or electronic circuits. These include liquid-line solenoid, suction-stop solenoid, inlet pressure-regulating valves, suction-stop pressure-regulating valves, and electronic regulating valves. For general information about refrigeration circuits, refer to the "[Glossary](#)" on page 35.

Verify that all circuits and valves open or close properly when activated. Pressure-regulating valves must be set to the suggested saturation suction temperature (SST) according to the circuit schedule. Use the controller to confirm parameters and adjust temperature set points for the electronic regulating valve circuits.

## Head Pressure Control Methods

### MECHANICAL INLET PRESSURE REGULATORS (HOLD-BACK VALVE)

Mechanical inlet pressure regulator valves must be field-set to maintain minimum condenser pressure (See Figure 14). For mechanical inlet regulators with electric wide open feature, the valve will be energized wide open when the inlet pressure exceeds the set point. We recommend setting the mechanical set point to an equivalent pressure converted to 60°F saturated condensing temperature. The electric wide-open feature is adjusted through the system controller.

# SYSTEM START-UP

The mechanical outlet pressure regulator needs to be adjusted while the mechanical inlet pressure regulator is operating. (See "[Mechanical Outlet Pressure Regulator \(Receiver-Pressurization Valve\)](#)").

## Setting for Ambient Temperature below 60°F

1. Ensure that the system is charged to 30-35% receiver level. If ambient subcooling is used, the ambient subcooling solenoid must be closed either manually or by lowering its set point.
2. Use the system controller to set condenser fans to run at 100%. Either lower the condenser set point or force each fan on individually. This will bypass any fan pressure or ambient controls.
3. Set mechanical inlet pressure regulator to an equivalent pressure converted to 60°F saturated condensing temperature. It is typically set 10-20 psig below the condenser fan set point.

## Setting for Ambient Temperature above 60°F

1. Ensure that the system is charged to 30-35% receiver level. If ambient subcooling is used, the ambient subcooling solenoid must be closed either manually or by lowering its set point.
2. Determine desired set point. Adjust hold-back valve to 75 psig above desired set point. After pressure is confirmed, turn the adjustment stem one turn counterclockwise to reach desired set point. (One turn equals approximately 75 psig of change.)

## MECHANICAL OUTLET PRESSURE REGULATOR (RECEIVER-PRESSURIZATION VALVE)

Mechanical outlet pressure regulator valves must be field-set to maintain minimum receiver pressure (See [Figure 14](#)). It should be set to 10 psig below the mechanical inlet pressure regulator set point.

### Setting Mechanical Outlet Pressure Regulator

1. After setting the mechanical inlet pressure regulator, set the receiver bypass valve, typically set 10 psig below the mechanical inlet pressure regulator (See "[Mechanical Inlet Pressure Regulators \(Hold-Back Valve\)](#)").
2. Isolate both ball valves and bleed pressure to suction. With outlet ball valve closed, open the inlet ball valve and slowly adjust outlet pressure regulator to 10-15 psig below the minimum inlet pressure regulator set point.

FIGURE 14: Mechanical Inlet or Outlet Pressure Regulator



# SYSTEM START-UP

## Heat Reclaim (or Heat Recovery)

Systems set up with heat reclaim (also known as heat recovery) can utilize either a motorized ball valve or a 3-way split valve.

### Motorized Ball Valve (MBV)

- Confirm isolation ball valves are open, that MBV motor is securely fastened to ball valve (can loosen during shipping), and that MBV opens and closes completely.
- Confirm that the pump out solenoid (if equipped) is de-energized when in heat reclaim. When not in heat reclaim, the heat reclaim circuit is pumped out to suction pressure.
- Cycle MBV in controller to confirm proper operation.
- The bypass check valve is supplied with a 10 lb. spring so the heat reclaim system does not exceed 10 lbs. maximum pressure drop.

### 3-Way Split Valve

- Confirm isolation ball valves are open.
- Confirm that the pump out flows through the 3-way split valve. When not in heat reclaim, the heat reclaim circuit is pumped out to suction pressure.
- Cycle 3-way split valve in controller to confirm proper operation.
- The bypass check valve is supplied with a 10 lb. spring so the heat reclaim system does not exceed 10 lbs. maximum pressure drop.

## Subcooling

Subcooling increases evaporator efficiency by delivering lower temperature liquid to the expansion valve, which reduces flash gas entering the expansion valve.

- Subcooling high-glide refrigerants require at least 10°F of subcooling at the expansion valve.
- Subcooler must be "OFF" during system start up and remain "OFF" until the system has been running and stabilized.
- Subcooler expansion valve superheat is typically set at 7-10°F.

*Note: A minimum of 20°F superheat and a maximum of 40°F superheat is allowed at all compressor suction service valves.*

### MECHANICAL SUBCOOLING (PLATE HEAT EXCHANGER)

A subcooler can be designed with either a thermostatic expansion valve (TEV or TXV) or electronic expansion valve (EEV) with electronic controller. Field adjustments will be completed manually or electronically, respectively.

- For reciprocating compressor systems: Typical liquid temperatures are 50°F with 40°F saturated suction temperature (SST).
- For low-temp scroll compressor systems: Typical liquid temperatures are 50°F with 40°F SST. Colder liquid temperatures are attainable with properly designed vapor-injected compressors. Medium-temp scroll compressor systems typically run warmer liquid temperatures.
- For low-temp screw compressor systems: Typical liquid temperatures are 50°F with 40°F SST. Colder liquid temperatures are attainable with properly designed economize screw compressors. Medium-temp screw compressor systems typically run warmer liquid temperatures.

### AMBIENT SUBCOOLING (RECEIVER BYPASS VALVE)

Ambient subcooling is a method of bypassing the receiver by providing liquid directly from the condenser to the liquid header. It increases evaporator efficiency by delivering subcooled liquid to the expansion valve when ambient temperatures are low enough to provide subcooling. Ambient subcooling is typically enabled below 65°F drop leg temperature. For field adjustments, refer to the controller set points.

# SYSTEM START-UP

The ambient solenoid or motorized ball valve in this bypass line is controlled by temperature on the drop leg refrigeration line. The program contains a 1-2 minute time delay to prevent erratic cycling.

**Typical factory set points for drop leg temperature:**

- 68°F drop leg liquid temp = Solenoid/MBV is closed.
- 65°F drop leg liquid temp = Solenoid/MBV is open.
- 10°F ambient temp = Solenoid/MBV is closed due to low ambient lock out temperature.
- 15°F ambient temp = Solenoid/MBV is open (allowed to cycle "ON") when ambient temperature is above low ambient lock out temperature.

## Low Load Bypass

### HOT GAS BYPASS/DE-SUPERHEATING

Hot gas bypass/de-superheating is applied to keep at least one compressor in a group running during low load conditions. Each valve is controlled by separate output points. The hot gas outlet regulator should be adjusted to maintain a suction pressure at or slightly below suction set point.

The expansion valve can be adjusted to increase the cooling of the discharge bypass gas to avoid overheating in the suction header. Monitor suction header temperature to ensure a minimum of 20°F superheat and a maximum of 40°F superheat.

## Start-Up Checklist

A start-up checklist is sent with the system. Look through the start-up checklist to ensure proper start-up was followed.

# MAINTENANCE & CLEANING

## Single-Circuit Shutdown (Short-Term)

**Note:** Identify whether the maintenance will require shutting down a single circuit or an entire system. Refer to the following instructions for proper single-circuit shutdown and start-up.

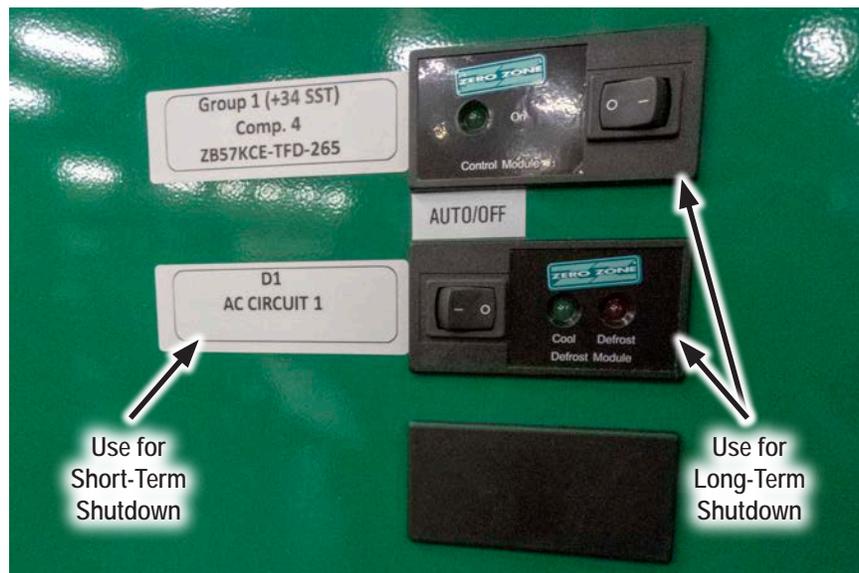
### SINGLE-CIRCUIT SHUTDOWN SEQUENCE

1. Install a manifold gauge downstream of the liquid isolation ball valve to monitor the pressure.
2. Close the liquid isolation ball valve.
3. Allow system to run long enough until the liquid refrigerant has boiled off.
4. Isolate the suction ball valve and defrost ball valve (if applicable).
5. Shut off control switch (See Figure 15).
6. Reclaim refrigerant from the circuit.
7. Repairs can now be made on that circuit.
8. Evacuate the circuit.

### SINGLE-CIRCUIT START-UP SEQUENCE

1. Turn on control switch.
2. Open the suction ball valve.
3. Open the liquid isolation ball valve.
4. Monitor the system to confirm normal operation.

FIGURE 15: Control Switch and Circuit Switch



# MAINTENANCE & CLEANING

## System Shutdown (Long-Term)

**Note:** *Identify whether the maintenance will require shutting down a single circuit or an entire system. Refer to the following instructions for proper refrigeration system shutdown and start-up.*

### SYSTEM SHUTDOWN SEQUENCE

**Note:** *Monitor the discharge pressure throughout the shutdown process. The receiver maximum pump down capacity is 80% full; do not overfill the receiver.*

1. Install a manifold gauge downstream of the liquid isolation ball valve to monitor the pressure.
2. Turn off mechanical subcooling (if applicable) by closing the liquid isolation ball valve.
3. Close the main liquid-line isolation ball valve.
4. Allow system to run long enough until the liquid refrigerant has boiled off.
5. Isolate the outlet oil reservoir service valves to contain oil inside the oil reservoir.
6. Close all circuit suction ball valves.
7. Turn off all circuit switches, then turn off all compressor control switches (See Figure 15 on page 30).
8. Turn off all compressor power breakers.
9. Turn off condenser power, following your company's lock-out/tag-out procedure.
10. Close main condenser isolation ball valves.

### SYSTEM START-UP SEQUENCE

1. At least 24 hours prior to starting the system, turn on compressor control switches. This will allow the crankcase heaters to heat the oil.
2. After 24 hours, shut off compressor control switches and turn on the compressor power breakers. Turn on each compressor control switch one at a time.
3. Turn on condenser power.
4. Open all circuit suction ball valves.
5. Open main liquid isolation ball valve to the system.
6. Turn on the circuit switches.
7. Allow system to run and stabilize.
8. Turn on mechanical subcooling (if applicable) by opening the liquid isolation ball valve.
9. After oil separator has warmed, open oil reservoir service valves.
10. Monitor the system to confirm normal operation.

# MAINTENANCE & CLEANING

## Filter Maintenance

For oil system maintenance, see "Oil System Maintenance" on page 34.

### LIQUID FILTER DRIER CORES

**CAUTION!** LIQUID FILTER DRIER CORES MUST BE IN PLACE DURING SYSTEM OPERATION. NEVER OPERATE SYSTEM WITHOUT DRIER CORES.

When the system is open to the atmosphere, drier cores should be replaced. A vacuum must be pulled after changing cores and before restarting system.

### SUCTION FILTER ELEMENTS

**CAUTION!** SUCTION FILTER ELEMENTS MUST BE IN PLACE DURING SYSTEM OPERATION.

Suction filter elements should be replaced once per year. A vacuum must be pulled after changing filters and before restarting system.

### SUCTION FILTER DRIER CORES

If the system becomes contaminated, various suction filter driers may be used to remove either moisture, acid, or other contaminants from the system. After the system is clean, remove the suction filter drier and replace with new suction filter element.

### OIL FILTERS (INLINE OR REPLACEABLE)

**CAUTION!** OIL FILTERS MUST BE INSTALLED DURING SYSTEM OPERATION. NEVER OPERATE THE SYSTEM WITHOUT OIL FILTERS.

Oil filters should be replaced once per year (See Figure 16). A vacuum must be pulled after changing oil filters and before restarting system.

FIGURE 16: Replaceable Core Oil Filter



# MAINTENANCE & CLEANING

## COALESCENT OIL SEPARATOR FILTER ELEMENT



**CAUTION!** COALESCENT OIL SEPARATOR WILL NOT SEPARATE OIL UNLESS THE FILTER ELEMENT IS IN PLACE DURING SYSTEM OPERATION. NEVER OPERATE SYSTEM WITHOUT FILTER ELEMENT.

Oil separator filter elements should be replaced when the indicator needle approaches the upper range (12 psig). When experiencing oil issues, replace with new oil filters.

*Note: If there is no differential pressure, this may indicate a blown out element (O-ring). A vacuum must be pulled after changing the element and before restarting the system.*

## Mechanical Maintenance

Perform mechanical maintenance every 3 months.

- Ensure Hydra-Zorb clamps are tight (See Figure 17).
- Inspect and tighten mounting screws/bolts on head fans.
- Ensure all screws are in place in solenoids.
- Listen for vibration, rattling, and other abnormal sounds.
- Visually inspect for signs of oil leakage.
- Check for refrigerant leaks.
- Check and record net oil pressure in compressors with oil pumps.
- Check oil levels in compressors and reservoirs.
- Inspect and tighten compressor mounting bolts.
- Observe superheat at compressors and adjust if necessary. Compressor manufacturers recommend a minimum of 20°F superheat and a maximum of 40°F superheat at the compressors.

FIGURE 17: Hydra-Zorb Clamps



## Electrical Maintenance



**DANGER!** TURN OFF ALL POWER FOLLOWING YOUR COMPANY'S LOCK-OUT/TAG-OUT PROCEDURE BEFORE CHECKING ANY WIRING CONNECTIONS.

Perform electrical maintenance once per year.

- Check compressor contactors for excessive pitting of contacts.
- Check and tighten electrical connections in electrical enclosures.
- Check and tighten energy management system (EMS) or low-voltage wiring.
- Check and measure supply voltages.
- Check and test alarm panel (if applicable) to confirm the audible alarm functions and alarm light illuminates during an alarm condition.

# MAINTENANCE & CLEANING

## Controls Maintenance

Perform control maintenance once per year.

- Check and tighten electrical connections to the controls.
- Inspect and test oil fail controls.
- Inspect and test low-pressure/high-pressure controls.
- Inspect and test refrigerant leak alarm.
- Inspect and test phase fail.

## Condenser Maintenance

Condensers should be cleaned quarterly or more often if condenser surface is visibly dirty. Perform condenser maintenance every 3-6 months.

- Check fan blades for cracks and excessive or unusual vibration.
- Check contactors for pitting.
- Check for oil leaks on header return bends and coil fins.
- Clean condenser coils and blades.
- Check and tighten electrical wiring and connections.

## Evaporator Maintenance

Evaporators should be checked monthly and cleaned at least annually. Perform evaporator maintenance every 3-6 months.

- Check fan blades for cracks and excessive or unusual vibration.
- Check for oil leaks on header return bends and coil fins.
- Check for refrigerant leaks.
- Clean evaporator coils, drain pans, and blades.
- Check and tighten electrical wiring and connections (for walk-in or industrial applications).

## Oil System Maintenance

Perform oil system maintenance every 3-6 months. For oil filter maintenance, see "[Filter Maintenance](#)" on page 32.

- Inspect the oil for discoloration or dirtiness.
- Check for oil leaks.
- Check oil levels in compressors and oil reservoir per manufacturer's specifications.
- Check coalescent oil separator differential (if applicable).

# GLOSSARY

## Accumulators

An accumulator prevents a sudden surge of liquid refrigerant or oil from returning down the suction line and into the compressor. The accumulator is a temporary reservoir for liquid refrigerant and oil. The accumulator is designed to meter both the liquid refrigerant and oil at a controlled rate back to the compressors. Accumulators can be orientated either vertically or horizontally, depending on requirements or preferences (See [Figure 18](#) and [Figure 19](#)).

FIGURE 18: Vertical Accumulator



FIGURE 19: Horizontal Accumulator



## Check Valves

Check valves allow refrigerant to flow in only one direction. Types include magnetic check valve or serviceable spring check valve.

### MAGNETIC CHECK VALVES

A magnetic check valve uses a magnet to control refrigerant flow. When there is pressure from the intended direction of flow, the pressure forces the magnet off of its seat and allows refrigerant to flow. When there is either no pressure or pressure against the intended direction of flow, the magnet pulls shut and restricts backward flow.

A magnetic check valve cannot be serviced and must be replaced if damaged.

### SERVICEABLE SPRING CHECK VALVES

A spring check valve uses a spring and piston to control refrigerant flow. When there is pressure from the intended direction of flow, the pressure forces the piston against the spring, which opens the port and allows refrigerant flow. When there is either no pressure or pressure against the intended direction of flow, the spring pushes the piston back, closes the port, and restricts backward flow.

The springs of spring check valves can be replaced with springs of different stiffness (tension), which will only allow refrigerant flow when enough pressure builds up.

## Compressors

Compressors convert low-pressure vapor refrigerant into high-pressure vapor. This can be accomplished with a scroll, reciprocating, or screw compressor.

### SCROLL COMPRESSOR

Scroll compressors use two interweaving scrolls to compress refrigerant vapor. One of the scrolls is fixed, while the other orbits without rotating, thereby trapping and compressing the vapor between the scrolls (See [Figure 20](#)).

FIGURE 20: Scroll Compressor



# GLOSSARY

## RECIPROCATING COMPRESSOR

Reciprocating compressors—also known as piston compressors—use pistons driven by a crankshaft to compress refrigerant vapor (See Figure 21). The vapor enters through the suction valve, pulled into the compression cylinder as the piston retracts. When the piston extends, both the suction valve shuts and the discharge valve opens, and the piston compresses the vapor into the discharge line.

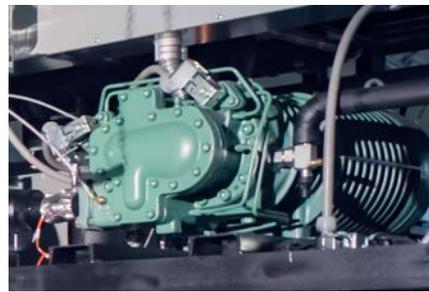
## SCREW COMPRESSOR

Rotary-screw compressors use two meshing helical screws, known as rotors, to compress refrigerant vapor (See Figure 22). Lubricating oil bridges the space between the rotors, both providing a hydraulic seal and transferring mechanical energy between the driving and driven rotor. Vapor enters at the suction side and moves through the threads as the screws rotate. The meshing rotors force vapor through the compressor, and the vapor exits at the end of the screws. To be effective, the clearances between rotors and chambers must be precise to seal the compression cavities. Some leakage is inevitable, but the leak rate can be minimized through high rotational speeds.

FIGURE 21: Reciprocating Compressor



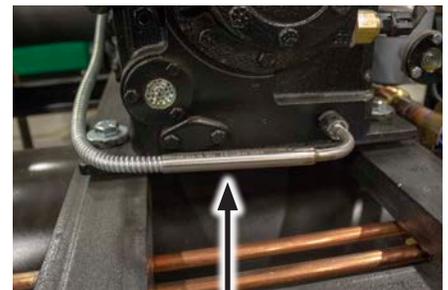
FIGURE 22: Screw Compressor



## CRANKCASE HEATER

The crankcase heater prevents refrigerant migration and mixing with crankcase oil when the unit is off (See Figure 23). When the unit is off, especially during a long shutdown, refrigerant will want to migrate to where the pressure is the lowest. The crankcase heater keeps refrigerant at a temperature higher than the coolest part of the system. The crankcase heater also prevents refrigerant condensation in the compressor crankcase.

FIGURE 23: Crankcase Heater



## PRESSURE CONTROLS

Pressure controls respond directly to changes in system pressure. When a preset pressure limit is reached, a dry contact is switched, which triggers a control circuit and sends an alert to the system controller. Pressure transducers measure pressure and provide constant pressure readings to the system controller.

The **high-pressure control** shuts off a compressor when the discharge pressure of the compressor exceeds the set point. The **low-pressure control** ensures the compressor does not run in a vacuum. It can also be set to maintain a desired temperature in the refrigeration system.

## COMPRESSOR SERVICE VALVES

The service valves located at the compressor allow the compressor to be isolated to measure refrigerant pressures.

## COMPRESSOR UNLOADERS

Compressor unloaders control capacity as the refrigeration load varies (See Figure 24 and Figure 25 on page 37). The suction line is typically blocked to prevent suction gas from entering the cylinder.

# GLOSSARY

FIGURE 24: Digital Unloader



FIGURE 25: Mechanical Unloader



## Condensers

Condensers remove heat from vapor refrigerant, allowing the high-pressure vapor to condense into a high-pressure liquid. Condensers typically release heat (which is absorbed in the evaporator) to either air or water.

### AIR-COOLED CONDENSERS

Air-cooled condensers are cooled by air which is forced over the coils that carry the vapor refrigerant.

### WATER-COOLED CONDENSERS

Water-cooled condensers are cooled by water that flows around the coils that carry the vapor refrigerant.

### LEAD FAN MOTOR

The lead fan motor must always be on the header end of the condenser. Manufacturers recommend that the lead fan motor runs all of the time. The only time that the lead fan motor should be turned off is if the condenser pressure falls too low during very low ambient temperature conditions. Proper control is necessary to prevent rapid cycling.

### ELECTRONICALLY COMMUTATED MOTORS (ECM)

An ECM is a commonly used condenser fan motor in condensers. ECMs may or may not be variable speed. ECMs are used because of their energy efficiency over a permanent split capacitor (PSC) motor.

### VARIABLE-FREQUENCY DRIVE (VFD)

A VFD—also known as an adjustable-frequency drive, variable-speed drive, AC drive, micro drive, or inverter drive—controls AC motor speed and torque by varying motor input frequency and voltage (See Figure 26).

### SPLIT CONDENSER

Typical split condensers are piped into two separate sides. One side is used all year, and the other side only operates during warm weather. This reduces the overall refrigerant charge required in cooler ambient conditions.

### Condenser Pump-Out

The condenser pump-out removes refrigerant from the idle side of a split condenser and pumps it back into the suction header. The refrigerant is then stored in the receiver.

FIGURE 26: Variable-Frequency Drive (VFD)



# GLOSSARY

## Split Condenser Valves

Split condenser valves control flow to split condensers and are located in the discharge line. When applied, the valves close one side of the condenser. Split condenser valves require the use of check valves in each drop leg for equal pressure drop. The check valves stop refrigerant migration from the receiver to the condenser while the condenser is not operating.

A **3-way split valve** diverts discharge gas to one or two outlets. One outlet is always open whether the valve is energized or not. When energized, the valve closes the second “split only” outlet, and refrigerant is pumped through the open outlet. When de-energized, the valve opens both outlets.

A **motorized ball valve** is installed on one of the two condenser inlet pipes. When it is closed, one side of the condenser becomes inactive.

A **normally-open solenoid valve** is installed on both inlet pipes to the condenser. When the solenoid coil is activated, the valve on one inlet pipe closes, causing one side of the condenser to become inactive. The valve on the other inlet pipe does not have a solenoid coil because this side will never be closed off. They are required on all split condenser inlets for equal pressure drop.

## RECEIVER VENT LINE

The receiver vent line connects the top of the receiver to the full-time side of the condenser discharge. A check valve is installed close to the discharge connection and allows refrigerant flow from the receiver to the condenser so the receiver pressure cannot become higher than the condenser pressure. The vent line allows free draining of the condenser.

## CONDENSER HEAD-PRESSURE CONTROL VALVE (INLET REGULATOR)

When applicable, the inlet regulator—also known as a hold-back valve or inlet pressure regulator (IPR)—is located in the common drop leg and maintains minimum condensing pressure. The inlet regulator must be field-adjusted to maintain proper pressure in the condenser.

## RECEIVER PRESSURIZATION VALVE (OUTLET REGULATOR)

When applicable, the outlet pressure regulator maintains a minimum receiver pressure by bypassing discharge gas directly to the receiver. The outlet regulator must be field-adjusted to maintain proper pressure in the receiver.

## Controller

The system controller energizes and de-energizes the system as needed. It controls many functions, including rack operation, defrost control, display case temperatures, discharge pressures, evaporator pressure, heat reclaim, facility lighting, and more.

## Defrost

Defrost is a process necessary for removing ice, snow, and frost accumulation on the evaporator coils. Each circuit of the system has a defrost schedule. An initial defrost program will be entered into the controller’s circuit control, and it must be field-verified or field-adjusted to ensure proper defrost. Each circuit includes an off/auto control switch and a light.

## ELECTRIC DEFROST

Defrost can be accomplished with electrical heaters embedded in the evaporator coils. The refrigerant flow to the evaporator is stopped by a control valve, and power to the heater is turned on. Evaporator fans are cycled off during this process.

## OFF-CYCLE DEFROST

Off-cycle defrost—also called off-time defrost—only works with medium temperature evaporators. It uses air in the refrigerated space to defrost the evaporator coil. During defrost, refrigerant flow to the evaporator is stopped by a control valve, and the evaporator fans continue to run.

# GLOSSARY

## GAS DEFROST

Defrost can be accomplished with warm refrigerant gas from either the discharge line or the top of the receiver. Gas defrost diverts hot gas or latent gas through the evaporator in defrost. The gas condenses in the evaporator and flows around the expansion valve and liquid-line solenoid valve. After defrosting the evaporator, the liquid refrigerant flows to the liquid header and is distributed to evaporators not in the defrost cycle.

Gas can be directed to the evaporator coil in two ways: either by reversing flow through the suction line back to the liquid header or through a dedicated third pipe. To reverse the flow, the pressure of the defrost header must be greater than the pressure of the liquid header. The difference in pressure is known as the defrost differential. Evaporator fans are typically cycled off during gas defrost.

### Hot Gas Defrost

Hot gas defrost uses discharge gas piped from between the oil separator and the condenser to defrost evaporator coils. Hot gas defrost is typically faster than latent gas defrost.

### Latent Gas Defrost

Latent gas defrost uses gas from the receiver to defrost evaporator coils.

### Defrost Gas Solenoids

Defrost gas solenoids control the flow of defrost gas into evaporators. The flow of liquid into the evaporator is turned off by a valve upstream of the evaporator, which opens the defrost gas valve to start the defrost cycle.

### Defrost Regulating Valves

Defrost regulating valves are used for hot gas or latent gas defrost to maintain differential pressure between the defrost header and the liquid header, allowing reverse flow during the defrost cycle. System elevation, length of runs, and other variables will determine the required differential pressure set point.

The discharge differential pressure regulator (DDPR) is located between the oil separator and the condenser in the main discharge line (See [Figure 27](#)). The liquid differential pressure regulator (LDPR) is located downstream of the filter dryer in the main liquid line (See [Figure 28](#)).

FIGURE 27: Discharge Differential Pressure Regulator (DDPR)



FIGURE 28: Liquid Differential Pressure Regulator (LDPR)



### Discrete Header

A discrete header can be used for gas defrost so that gas does not return to the liquid header but instead moves upstream of the condenser. Instead of bypassing the gas around the liquid-line solenoid into the liquid header, it is bypassed back to the discharge line downstream of the discharge differential pressure regulator valve.

# GLOSSARY

## Electrical Components

### PHASE MONITOR

A phase monitor continuously monitors incoming line voltage to protect from premature failure and damage due to voltage imbalance, high and low voltages, phase loss, phase reversal, or incorrect sequencing (See Figure 29).

### CONTROL RELAY (ICE CUBE/PLUG-IN RELAY)

A control relay—also known as an ice cube relay or plug-in relay—is a small electrical switch that is housed in clear plastic (See Figure 30). It acts as a simple “on/off” switch with no intermediate states.

### POWER DISTRIBUTION BLOCK (PDB)

A PDB distributes power throughout the electrical system and components (See Figure 31).

### COMPRESSOR CONTROL MODULE

The compressor on/off switch is typically mounted on the electrical box of the compressor (See Figure 32). It includes control fusing and an indicating light, and it will shut off the compressor in the event of a failure caused by compressor motor overloading or high discharge temperature.

### DEFROST CONTROL MODULE

A defrost on/off switch is typically mounted onto the electrical control panel (See Figure 33). It includes control fusing and indicating lights.

### CONTACTOR

A contactor is an electrically controlled switch used for switching an electrical power circuit, similar to a relay except with higher current ratings. A contactor is controlled by a circuit which has a much lower current level than the switched circuit.

### AUXILIARY CONTACTS (CONTACTOR)

An auxiliary contact is a low current switch located on, or mounted to, a contactor. It is often used in a relay logic circuit or crankcase heater.

### CIRCUIT BREAKER

A circuit breaker is a thermal magnetic device used as a disconnecting means and as a safety device to protect against short circuiting.

### TRANSFORMER

A transformer is used to reduce incoming voltage for controls and secondary voltage.

FIGURE 29: Phase Monitor

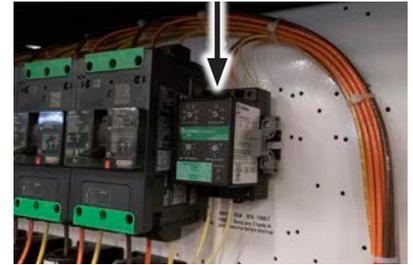


FIGURE 30: Control Relay



FIGURE 31: Power Distribution Block (PDB)



FIGURE 32: Compressor Control Module



FIGURE 33: Defrost Control Module



# GLOSSARY

## Evaporators

Evaporators transfer heat from a refrigerated space—such as a walk-in, a display case, or an industrial site—to cool the refrigerated space and product stored inside it. Low-pressure liquid refrigerant enters the evaporator, and it evaporates into vapor as it absorbs heat from air inside the refrigerated space. It exits the evaporator as a low-pressure vapor refrigerant.

## Expansion Valve

The expansion valve—also known as a metering device—restricts and controls the flow of refrigerant into the evaporator. Since only a small amount of refrigerant flows through the expansion valve, it does not fill the available space in the evaporator, causing pressure to drop and the refrigerant to expand. The refrigerant enters the expansion valve as a high-pressure liquid refrigerant, and it exits as a low-pressure liquid.

### THERMOSTATIC EXPANSION VALVE (TEV)

A thermostatic expansion valve may also be called a thermal expansion valve and is abbreviated as either **TEV** or **TXV**. The TEV controls the flow of refrigerant by using a temperature sensing bulb that is filled with a similar gas as in the system (See Figure 34). When the temperature of the bulb increases, the valve opens against the spring pressure in the valve body. When the temperature decreases, the valve closes. A TEV must include an equalizer line to allow for the pressure drop across the evaporator when distributor tubes are used.

### ELECTRONIC EXPANSION VALVE (EEV)

An electronic expansion valve controls the flow of refrigerant according to signals received from an electronic controller (See Figure 35).

FIGURE 34: Thermostatic Expansion Valve (TEV)



FIGURE 35: Electronic Expansion Valve (EEV)



## Head-Pressure Control Methods

Head-pressure controls maintain minimum condensing pressure. Head-pressure controls can be mechanical or electronic.

### FAN CYCLING

Head pressure can be controlled by modulating the amount of cooling in the condenser by cycling fans on and off. With fewer fans running, the cooling capacity is lessened and the head pressure will increase.

### CONDENSER FAN MOTORS WITH VARIABLE FREQUENCY DRIVE (VFD)

Head pressure can be controlled by condenser fans on a variable frequency drive that can be sped up or slowed down, which modulates air flow over the condenser coil and the amount of heat removed from the condenser.

# GLOSSARY

## CONDENSER FLOODING

Head pressure can be controlled using an inlet pressure regulator (IPR), known as a head-pressure control valve, on the condenser drop leg line. When head pressure gets low, the valve will shut. This increases the pressure in the condenser and blocks liquid refrigerant, which floods portions of the condenser. The flooded area of the condenser will have little heat transfer and lessen the heat transfer of the condenser which will increase the head pressure. Subcooling reduces flash gas entering the expansion valve by ensuring that only liquid refrigerant enters the expansion valve. Subcooling can be set up within the condenser (ambient subcooling) or through a heat exchanger (mechanical subcooling).

## Heat Reclaim (or Heat Recovery)

A refrigeration system can be set up with heat reclaim (also called heat recovery). Heat reclaim uses exhausted heat from the condenser for space heating, water heating, or dehumidification. Heat reclaim uses heat that is typically released at the condenser. Heat reclaim is set up in the discharge line between the separator and the condenser. It is controlled by a reclaim valve.

### AIR RECLAIM (SPACE HEATING)

Air reclaim uses heat from the refrigeration system for space heating in a building. The discharge gas is piped into a space heating coil, and fans force air over the coil to remove heat from the discharge gas. This is typically a fin and tube coil mounted in the HVAC equipment. Air reclaim requires a signal from the HVAC controller.

### WATER RECLAIM (WATER HEATING)

Water reclaim uses heat from the refrigeration system for water heating. The discharge gas is piped into a water heater where the heat is transferred into the water from the discharge gas. This is typically a water heater tank with a double-walled heat exchanger. Water reclaim is controlled by temperature sensors and the refrigeration system controller.

## RECLAIM VALVES

Reclaim valves divert the discharge gas between the separator and the condenser to a reclaim component. After exiting the reclaim component, the gas moves to the condenser.

### Reclaim Solenoid Valve

A reclaim solenoid valve diverts discharge gas to one of two outlets. The valve switches between the two outlets when the solenoid is activated electronically. The two outlets either discharge refrigerant to a reclaim system or bypass the reclaim system directly to the condenser.

### Reclaim Motorized Ball Valve

Reclaim motorized ball valves (MBV) divert discharge gas from the discharge line to a reclaim system. The two valves are always in opposite states of open or closed. In reclaim mode, the MBV piped to the reclaim system is open and the MBV piped to the condenser is closed. In reclaim bypass mode, the MBV piped to the reclaim system is closed and the MBV piped to the condenser is open.

### Reclaim 3-Way Motorized Ball Valve

A 3-way motorized ball valve diverts discharge gas to one of two outlets. The valve switches between the two outlets when an electronic actuator receives an electronic signal to turn the valve stem. The two outlets discharge to either a reclaim system or bypass the reclaim system directly to the condenser.

### Reclaim 2-Way/3-Way Motorized Ball Valve

This valve is a typical 2-way ball valve with a 24 volt motor mounted to the operating stem. When the clockwise lead is energized, the valve rotates closed. When the counter clockwise lead is energized, the valve rotates open. The motor can be removed for manual service or temporary shutdown. The ball valve is not designed to be a modulating valve.

# GLOSSARY

## Hot Gas Bypass

Hot gas bypass keeps a single compressor running under low load capacity without short cycling.

## Isolation Valves

Isolation valves are used to stop flow (See Figure 36). When two or more isolation valves are closed on a run of pipe or region of a system, it isolates that part of the system. This allows for refrigerant to be evacuated and service to be performed on any of the components in the isolated region.

FIGURE 36: Isolation Valve



## Liquid Filter Drier

The liquid filter drier is located in the outlet liquid line after the receiver. It removes moisture, foreign particles, and acid from the system. Replaceable cores for the drier shells must be field-installed.

## Oil System

### OIL FILTER

Oil filters, located between the oil separator and oil header, removes contaminants in the oil to protect the compressors. If the system is not filtered, dirt and other solid contaminants (such as metallic particles) will flow into the compressor. Oil filters are designed to remove 99% of debris down to 3 microns while maintaining sufficient flow at a low-pressure drop.

#### Inline Oil Filter

An inline oil filter must be replaced when it becomes full of contaminants (See Figure 37). To replace, unbrazed or unscrew the entire filter from the system and replace with a new oil filter.

#### Replaceable Core Oil Filter

A replaceable core oil filter must be replaced when it becomes full of contaminants (See Figure 38). To replace, the shell can be disassembled by unscrewing the plate cover, and then replace it with a new oil filter.

FIGURE 37: Inline Oil Filter



FIGURE 38: Replaceable Core Oil Filter



# GLOSSARY

## OIL SEPARATOR

The oil separator, located in the discharge line, separates oil from discharge gas and returns the oil to the compressor. The discharge gas continues to the condenser.

Oil enters the separator as a misty mixture of oil and discharge gas. As this mist enters the large internal volume of the separator, its velocity immediately decreases. This low velocity is the key to oil separation. The mist flows into internal baffling, which forces the mist to change direction. At the same time, the mist is slowing down rapidly on the surface of the baffles. Very fine oil particles collide with one another and form heavier particles. A fine mesh screen separates the oil and discharge gas, causing large oil droplets to form and drop to the bottom of the separator, where the oil will return to the compressor crankcase.

### Coalescent Separators

In a coalescent oil separator, refrigerant mass flow pressure moves the mixture of oil and discharge gas (See Figure 39). A filter of highly pure glass fibers separates the oil from the discharge gas by forcing the oil particles to collide and form larger droplets, which then move through a drain layer. The oil droplets accumulate and fall into the bottom of the separator (wet zone), and the clean oil returns to the compressor. The clean gas moves upward (dry zone) to the condenser.

### Helical Separators

In a helical separator, the mixture of oil and discharge gas moves in a spiral motion around the separator (See Figure 40). Centrifugal force causes heavier oil particles to spin toward the perimeter, where they impact an internal screen. The screen strips oil from the discharge gas. The oil droplets flow down the screen through a baffle and into an oil collection chamber. The clean gas exits through a screen at the bottom.

The internal reservoir of a helical separator does not include an oil float. Instead, a dip tube in the oil collection chamber feeds oil to the compressor through a high-pressure oil management system.

### Impingement Separators

In an impingement separator, the mixture of oil and discharge gas passes through an inlet screen, causing oil particles to combine into larger droplets and fall into the bottom of the separator (See Figure 41). The separated gas passes through an outlet screen to remove residual oil particles.

Once enough oil collects in the bottom of the separator, the float will rise and the needle valve will open, allowing oil to move to the oil reservoir. The pressure difference between the oil separator and oil reservoir allows this movement to happen.

FIGURE 39: Coalescent Oil Separator



FIGURE 40: Helical Oil Separator



FIGURE 41: Impingement Oil Separator



### Oil Separator Float

Most separators include an internal oil float. When enough oil collects in the separator, the oil float opens and the oil moves to the oil reservoir.

# GLOSSARY

## OIL RESERVOIR

The oil reservoir holds reserve oil supply until the compressor oil float detects that more oil is needed. This storage vessel also holds oil that is removed from the oil separator.

An **external oil reservoir** is typical for low-pressure oil systems and works in combination with a coalescent, helical, or impingement separator (See Figure 42).

An **integral oil reservoir** is typical for high-pressure oil systems and works in combination with a coalescent or helical separator. An integral oil reservoir is attached to the bottom of the oil separator. It is divided from the separator by baffles, which protects the oil in the reservoir from the turbulent action of the oil separator.

### Oil Level Regulators

The oil level regulator controls the oil flow to a compressor crankcase to maintain the oil level specified by the compressor manufacturer.

A **mechanical oil level regulator** controls the oil level in the compressor crankcase with a float-operated mechanical valve. It is mounted directly to the compressor crankcase sight glass location.

An **electronic oil level regulator** has an electronic level detector (float and hall sensor) that monitors the oil level and transmits data to the control logic. The integrated solenoid valve feeds oil directly into the compressor sump when the compressor oil level is low. If the proper oil level cannot be reached, the oil regulator sounds an alarm. The alarm contacts can be used to shut down the compressor.

### Mechanical Oil Pressure Regulators

Mechanical oil pressure regulators maintain a maximum oil header pressure above the compressor crankcase.

### Oil Reservoir Check Valve (OCV)

The oil reservoir check valve allows the pressure to be relieved from the reservoir to the suction as required to maintain a maximum oil header pressure above the compressor crankcase (See Figure 43). The OCV generally maintains a differential pressure of 20 psig.

## OIL SERVICE VALVE

The oil service valve isolates the reservoir and provides service access to measure oil pressure.

## OIL REDUCING VALVE

The oil reducing valve, used on a high-pressure oil system, reduces the oil pressure differential to the oil float. Excessive oil pressure will cause oil to leak through the float, which will overfill the compressor.

## LIQUID SIGHT GLASS

The liquid sight glass, located between the liquid-line driers and liquid header, shows how much liquid and gas refrigerant exists in the system (See Figure 44). The liquid should be shown as a solid column with no gas bubbles. If there are bubbles or flash gas, there may be a problem in the system. Green typically indicates dry; yellow indicates moisture.

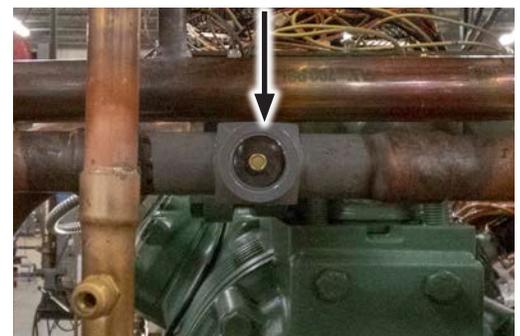
FIGURE 42: External Oil Reservoir



FIGURE 43: Oil Reservoir Check Valve (OCV)



FIGURE 44: Liquid Sight Glass



# GLOSSARY

## OIL FAIL CONTROLS

The compressor requires oil for lubrication. To ensure adequate oil pressure, an oil fail control senses the pressure (See Figure 45). If there is inadequate oil pressure, the oil fail control begins a time delay; if the oil pressure does not recover to a safe level within the time delay, the compressor is shut down. The time delay should allow the compressor adequate time to establish proper oil pressure and avoid a shutdown.

## Oversized Suction Headers

A suction header can effectively act as an accumulator if it is oversized from what is required by line size calculations (See Figure 46). The additional space acts as storage for liquid refrigerant. It meters both the liquid refrigerant and oil at a controlled rate back to the compressors.

FIGURE 45: Oil Fail Control



FIGURE 46: Oversized Suction Header



## Pressure Control Valves

Pressure control valves can stop, regulate, or bypass flow of refrigerant. Pressure control valves can be installed in various parts of the system, depending on need.

### MECHANICAL PRESSURE-REGULATING VALVES

Mechanical pressure-regulating valves alternate between open or closed by using springs and/or pilot pressure (See Figure 47 on page 47). A solenoid may be used in conjunction to shut off flow.

### ELECTRONIC PRESSURE-REGULATING VALVES

Electronic pressure-regulating valves alternate between open or closed by using electric step motor, which receives signals from an external controller (See Figure 48 on page 47). The valve can be used to shut off flow.

### LIQUID-LINE OUTLET PRESSURE REGULATOR (LL-OPR)

The LL-OPR maintains a constant liquid supply pressure to the evaporator expansion valves. Mechanical subcooling is required with this application.

## Pressure Transducer Valves

Pressure transducer valves are used for installing pressure transducers for pressure readings (See Figure 49 on page 47). Pressure transducer valves can be located in the suction header, discharge header, and condenser return lines.

# GLOSSARY

FIGURE 47: Mechanical Pressure-Regulating Valve



FIGURE 48: Electronic Pressure-Regulating Valve



FIGURE 49: Pressure Transducer Valve



## Receiver

The receiver holds excess liquid refrigerant when load conditions are low. It also helps provide a constant supply of refrigerant to the expansion valve. This prevents refrigerant from being backed up in the condenser. Receivers can be either vertical or horizontal, depending on size limitation and preference.

A **horizontal receiver** can use an optional mechanical liquid-level float: visual, analog, or digital. If the horizontal receiver is larger than 24" in diameter, it will require exterior liquid-level columns.

A **vertical receiver** can use a continuous read-out liquid-level probe or electronic eye.

### RECEIVER LIQUID-LEVEL MONITORING

Liquid-level monitors are used to ensure that there is always liquid in the receiver so that liquid can always be fed to the expansion valve.

#### Liquid-Level Probe

The liquid-level probe is a continuous analog read-out device typically used with vertical or horizontal receivers. Probes are typically powered and connected to the system control board.

#### Liquid-Level Analog Float

The liquid-level analog float is a continuous read-out device with visual dial typically used with horizontal receivers. It includes an articulating linkage and a ball float connected to a magnetic dial.

#### Float Switch Relay

The float switch relay provides a low level alarm contact closure plus visual read-out. The low level alarm is field adjustable, and used as an alternative to the analog float. It includes an articulating linkage and a ball float connected to magnetic dial.

#### Electronic Eye

The electronic eye uses light reflecting from a conical glass prism to detect when the glass cone is empty. When no fluid covers the lower half of the cone, infrared light from the module reflects from the mirror-like inner surface of the cone back to a light detector, signaling the electric module to switch on. When fluid covers the lower half of the glass cone, the light from the module passes into the fluid. The module detects the absence of light and switches off.

#### Visual Float

The visual float does not have any electronic components. It includes articulating linkage and a ball float connected to a magnetic dial. The float provides a direct percentage reading of the refrigerant level pumpdown capacity.

# GLOSSARY

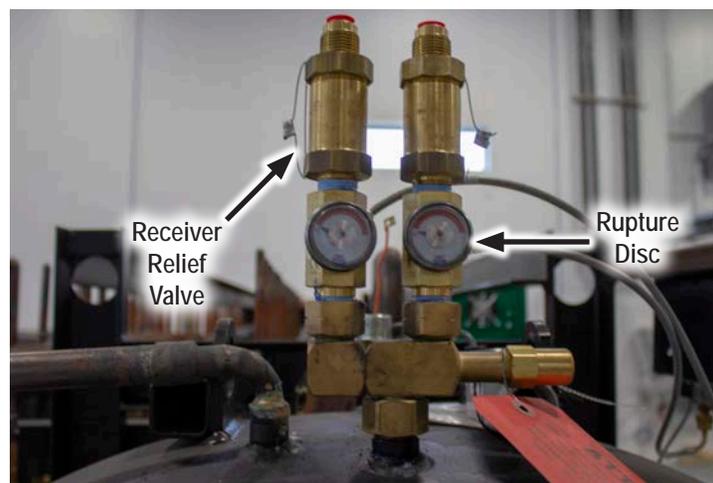
## RECEIVER RELIEF VALVES

The receiver relief pressure valve automatically releases refrigerant from the receiver when the pressure exceeds the set point (See Figure 50). The relief valve is located in the vapor space, not the liquid space. The relief valve releases vapor, which cools the remaining liquid and lowers the pressure in the receiver.

## RUPTURE DISCS

A rupture disc is an optional device that can be installed between the pressure relief valve and receiver (See Figure 50). The rupture disc indicates over-pressurization. When the system pressure is too high for safe operation, the rupture disc will burst and release gas downstream to the relief valve. After the disc has ruptured, it must be replaced.

FIGURE 50: Receiver Relief Valve and Rupture Disc



## HI-LOW BYPASS VALVE

The bypass valve is connected to the pressure vessel and the suction header. In the event of a high-pressure spike, the valve bypasses excess pressure to the low side of the system, which prevents the pressure relief valve from discharging refrigerant into the atmosphere. If the pressure increases, the pressure relief valve will be activated.

Bypassing refrigerant for extended periods of time can lead to loss of system capacity, excessively high compressor temperatures, and possible compressor failure. It should only be used for high-pressure spikes and not for continuous bypass.

## Refrigeration Circuits

### LIQUID-LINE SOLENOID

The liquid-line solenoid is a valve that is closed when de-energized, and it must be energized to open during the refrigeration cycle. Its primary function is to prevent refrigerant from flowing into the evaporator during off cycle. It may also be used with defrost.

### SUCTION-STOP SOLENOID

The normally-closed suction-stop solenoid is a valve that energizes to open, which allows refrigerant to flow through the valve. The solenoid will remain open during normal operation, and it closes for defrosting or temperature control.

# GLOSSARY

## NORMALLY-OPEN SOLENOIDS

The normally-open solenoid is a valve that energizes to close, which stops refrigerant from flowing through the valve. When de-energized the valve allows refrigerant to flow. This valve is typically used for split condenser operation.

## Service Access Ports

Service access ports are available for attaching gauges for evacuation, charging, and pressure testing (See Figure 51).

FIGURE 51: Service Access Port



## Solenoid Valves

Solenoid valves are electromechanically operated valves that control refrigerant flow. They are either open or closed; they do not modulate.

## Subcooling

### AMBIENT SUBCOOLING

Ambient subcooling (also called natural subcooling) works within the condenser. When the ambient air around the condenser is cooler than the condensing temperature, the heat from the refrigerant can be transferred to the ambient air, which subcools the refrigerant. Ambient subcooling is cycled on and off based on whether the ambient air is cooler or warmer than the condensing temperature. Either a motorized ball valve or a solenoid valve can be used to cycle subcooling.

### MECHANICAL SUBCOOLING

Mechanical subcooling may be accomplished using either a liquid/suction heat exchanger or a subcooler heat exchanger.

#### Liquid/Suction Heat Exchanger

Mechanical subcooling with a liquid/suction heat exchanger works by subcooling the refrigerant supplied to the evaporator and also superheating the refrigerant exiting the evaporator. A heat exchanger allows heat to transfer from the liquid refrigerant to the gas refrigerant. This heat transfer superheats the gas and subcools the liquid simultaneously.

# GLOSSARY

## Subcooler Heat Exchanger

Mechanical subcooling with a subcooler heat exchanger works by subcooling the liquid refrigerant on one side of the heat exchanger using direct expansion evaporation on the other side of the heat exchanger (See [Figure 52](#) and [Figure 53](#)). An expansion valve regulates refrigerant flow into the heat exchanger on the evaporation side, and then the superheated refrigerant returns to the compressor suction. The subcooled liquid temperature is usually controlled to a specified value.

## Suction Filters

The suction filter is located in the suction line, upstream of compressors. It protects the compressor by removing contaminants. The filter core must be replaced if it allows contaminants into the system.

FIGURE 52: Subcooler/Heat Exchanger (Uninsulated)



FIGURE 53: Subcooler/Heat Exchanger (Insulated)







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