Application Guidelines for Invotech YF

Scroll Refrigeration Compressors

Safety Instructions

Invotech Scroll compressors are manufactured according to the latest European Safety Standards (already got the CE approvals). Safety instructions are applicable to the products below.
These instructions should be retained throughout the lifetime of the compressor. You are strongly advised to follow these safety instructions, also the local related rules should be obeyed.

Safety Statements

- Refrigerant compressors must be employed only for their intended use.
- Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission and maintain this equipment.
- Electrical connections must be made by qualified electrical personnel.
- All valid standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment must be observed.

ELECTRICAL SHOCK HAZARD

- Disconnect and lock out power before servicing.
- Discharge all capacitors before servicing.
- Use compressor with grounded system only.
- Molded electrical plug must be used when required.
- Refer to original equipment wiring diagrams.
- Electrical connections must be made by qualified electrical personnel.
  Failure to follow these warnings could result in serious personal injury.

PRESSURIZED SYSTEM HAZARD

- System contains refrigerant and oil under pressure.
- Remove refrigerant from both the high and low compressor side before removing compressor.
- Use appropriate back up wrenches on rota-lock fittings when servicing.
- Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.
- Use only approved refrigerants and refrigeration oils.
- Personal safety equipment must be used.
- Failure to follow these warnings could result in serious personal injury.

BURN HAZARD

- Do not touch the compressor until it has cooled down.
- Ensure that materials and wiring do not touch high temperature areas of the compressor.
- Use caution when brazing system components.
- Personal safety equipment must be used.
- Failure to follow these warnings could result in serious personal injury or property damage.

Introduction

The YF Invotech Scroll™ compressor represents the latest generation of compliant scroll technology for the refrigeration industry of low temperature application. YF Scroll compressors are special designed for the low temperature applications, including the special scroll form design, dynamic discharge valve, injection system, etc. These special designs result in a compressor that is suitable for the most demanding refrigeration applications with efficiencies comparable to the semi-hermitic compressor.

Nomenclature

The YF scroll model numbers include the nominal refrigeration capacity at standard 50HZ ARI rating conditions for low temperature (-31.7/40.6°C). For additional information on this product, please refer to the online information accessible from the Invotech Scroll Technologies web site at www. invotech.cn.

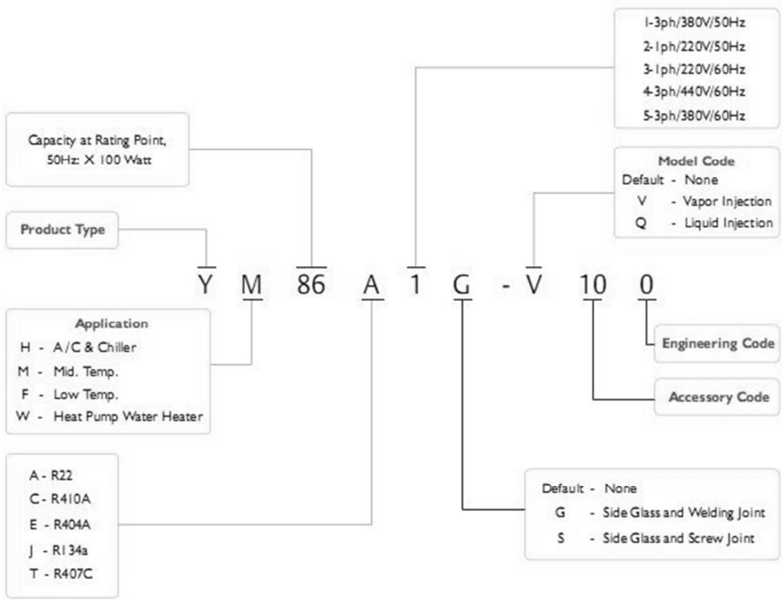


Figure 1 YF Nomenclature

Operating Envelope

The YF refrigeration scroll compressor models can be used with R22 or R404A refrigerants depending on the model selected and the lubricant used.

The YF**A and YF**E models are intended for low temperature refrigeration type duty. The approved operating envelopes for these models are such that they are ideally suited for applications such as environmental test chamber, refrigeration display cabinets and frozen cave, etc. The models and operating envelopes are depicted in Figures 2a and 2b.

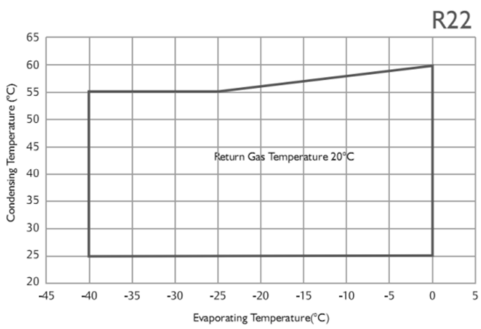


Figure 2a

YF**A Application Envelope for R22

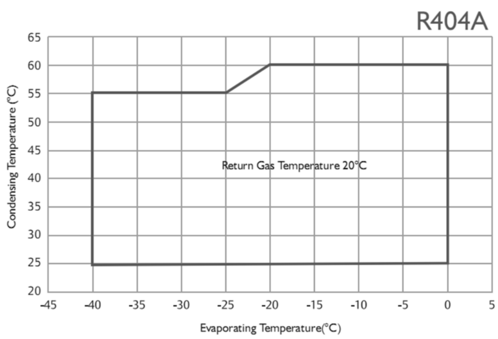


Figure 2b

YF**E Application Envelope for R404A

Liquid Injection

The low temperature scroll compressor is provided with an injection port suitable for connection to a source of liquid refrigerant. Internally, this port is connected to an inner pocket of the scroll mechanism. Since this pocket is separated from the suction inlet, no loss of capacity or mass flow results from injecting at this point.

Refrigerant injected in this manner must include the system components listed on the following instructions. Failure to follow these instructions can result in liquid refrigerant completely filling the scroll during an “off” cycle. When power is reapplied in this condition, the hydraulic effect produced can result in pressures high enough to cause permanent damage to the compressor. It is a condition of warranty that these components are properly installed.

- Capillary Tube - Liquid must be fed through an appropriate capillary tube as defined in Table 1, Not required if DTC valve is used.

Model	Cap Tube		Model	Cap Tube	
	I.D.	Length		I.D.	Length
	(mm)	(mm)		(mm)	(mm)
R-22			R-404A/R-507/R-134A		
YF13A1	1	1800	YF13E1	1	1800
YF20A1	1	800	YF20E1	1	1800
YF29A1	1	260	YF29E1	1	1100
YF35A1	1	130	YF35E1	1	800
YF41A1	1.25	130	YF41E1	1	520

Table 1 Capillary Tubes For Liquid Injection

- Solenoid Valve - A solenoid valve with a minimum 3mm orifice must be provided in the injection circuit that opens whenever the compressor is operative or cooling is required during pump down. The solenoid must be closed when the compressor is cycled off. NOTE: Not required if DTC valve is used.
- Current Sensing Relay - To prevent the solenoid from remaining open during a “motor protector trip,, a current sensing relay must be provided that senses whenever the compressor is “off, and closes the solenoid to stop injection. NOTE: Not required if DTC valve is used

The following components are not required, but they are recommended for liquid injection.

- Sight Glass - A sight glass just before the capillary tube inlet is recommended to allow visual inspection for the presence of liquid refrigerant.
- Filter/Drier - A filter/drier installed in the injection circuit is recommended to avoid the possibility of capillary tube blockage due to contaminants.

Figure 3 is a representation of a typical system with these components.

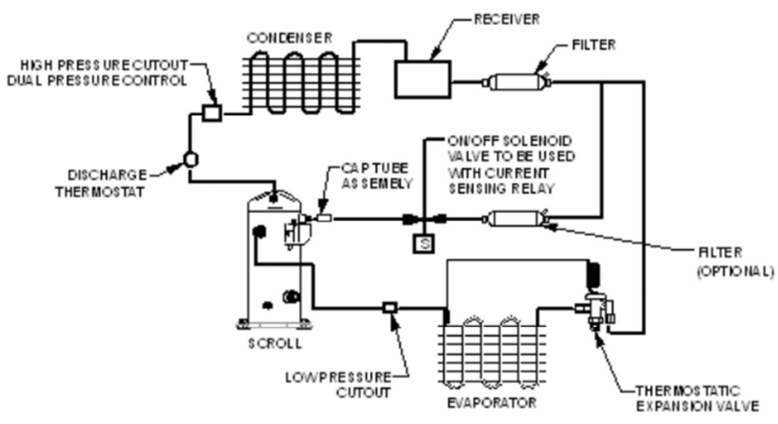


Figure 3 YF Liquid Injection with Cap. Tube

The advantage of this type of injection system is that it tends to be self regulating i.e., as the pressure differential across the capillary tube increases, the amount of liquid fed to the compressor also increases. Since more cooling is needed at high compression ratio conditions, this “automatic” increase in liquid feed is exactly what is needed.

For the liquid injection system to be effective, a minimum of 3K sub-cooled liquid at the capillary inlet is required. However, DO NOT use mechanically cooled sub-cooled liquid. The cap tube will be oversized under this condition and will dilute the oil in the compressor crankcase

Temperature Responsive Expansion Valve Introduction

It is possible to use a TXV type valve to realize the liquid injection. This special type of TXV valve is called temperature responsive expansion valve.

When the discharge temperature is higher than the settings, the valve will open, and the valve opening degree is based on the discharge temperature which detected by the bulb. Liquid refrigerant will be fed into the injection port, the injection flow will changed according to the discharge temperature.

The purpose of this valve is to eliminate the need for a capillary tube on the "YF" scroll model family.

Suggested valve specifications

Opening Setpoint: 90℃ ±3℃

Installation of Valve (see Figure 4)

The valve bulb must be installed in the top cap thermal well to adequately control scroll temperatures. The valve should be tightened on the injection fitting to a torque of 25 - 28 Nm. A 90° orientation on the valve is recommended, however it will function properly in any orientation. The capillary tube connecting the valve to the bulb should be positioned such that it does not contact the compressor during operation. Do not bend the capillary tube within 25mm of the valve.

The DTC Valve comes with an insulating cap. If this additional height from the cap is an issue, the valve cap could be replaced with high temperature insulation. This should be applied to insulate and protect the valves remote bulb assembly. This will reduce the total height requirement by 13mm.

Suggested Application Techniques

For the most efficient thermal sensing, spread a thin film of thermal grease around the DTC Valve bulb before installing into the top cap well. However for proper functioning of the valve this is not required.

At your discretion, field serviceability can be improved by installing a shut-off valve in the liquid line just before the DTC Valve.

The valve requires a solid column of liquid. A liquid line sight glass could be applied to visually insure liquid flow.

Compressor or Valve Service

Replacing a YF compressor using capillary tube, liquid injection solenoid and current sensing relay：

The YF compressor and DTC Valve eliminate the need for the solenoid and current sensing relay. These devices may be left on if desired, but they are not required.

Replacing a YF compressor using the DTC Valve:

We recommend replacing both the DTC Valve and the compressor at the same time. If you wish to use the existing DTC Valve, the valve filter should be taken out and cleaned and/or replaced.

Replacing a DTC Valve on a YF compressors:

Before replacing the DTC Valve, clean and/or change the filter to verify there is an unobstructed column of liquid to the valve.

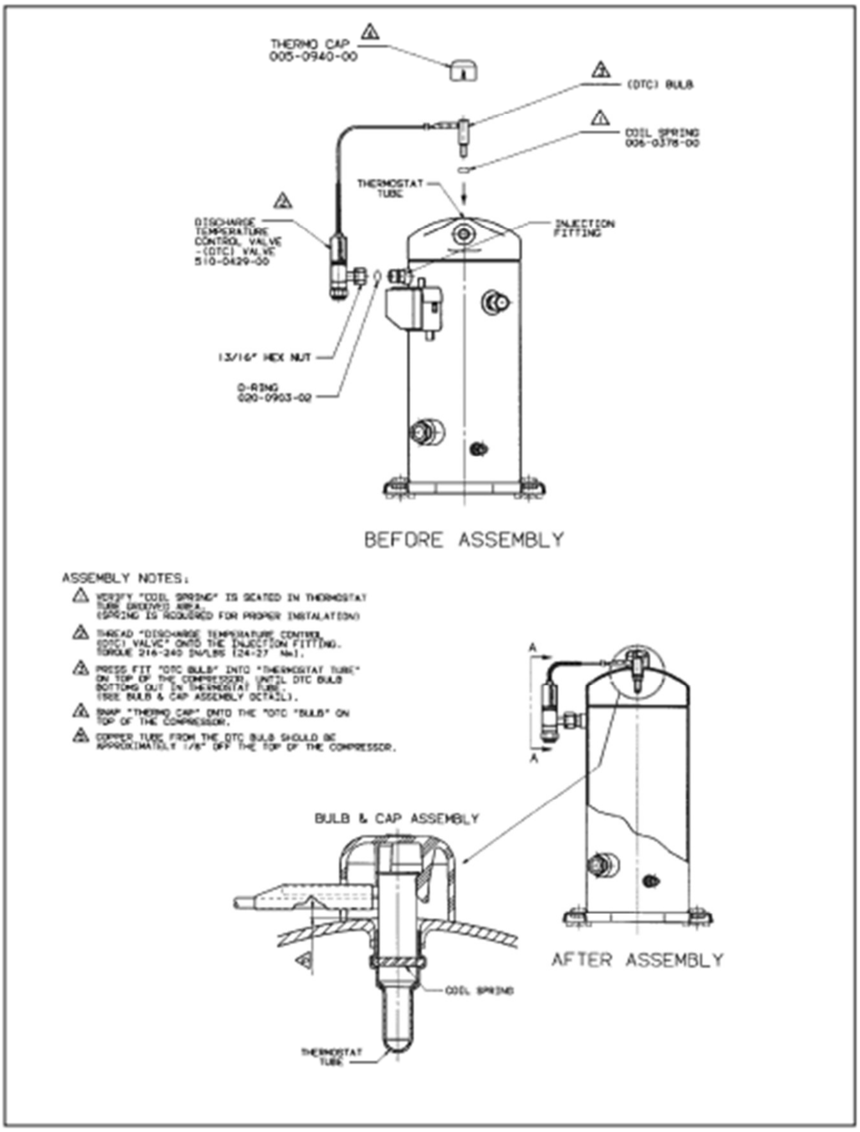


Figure 4   YF Liquid Injection with Temperature Responsive Valve

Accumulators

Due to the inherent ability of Invotech Scroll to handle liquid refrigerant in flooded start and defrost cycle operation conditions, accumulators may not be required. An accumulator is suggested on single compressor systems when the charge limitations exceed 5kg. On systems with defrost schemes or transient operations that allow prolonged uncontrolled liquid return to the compressor, an accumulator is required unless a suction header of sufficient volume to prevent liquid migration to the compressor is used.

Excessive liquid flood back or repeated flooded starts will dilute the oil in the compressor causing inadequate lubrication and bearing wear. Proper system design will minimize liquid flood back, thereby ensuring maximum compressor life.

In order to assure that liquid refrigerant does not return to the compressor during the running cycle, attention must be given to maintaining proper superheat at the compressor suction inlet. Invotech recommends a minimum of 11K superheat, measured on the suction line 150mm from the suction port, to prevent liquid refrigerant flood back.

Another method to determine if liquid refrigerant is returning to the compressor is to accurately measure the temperature difference between the compressor oil crankcase and the suction line. During continuous operation we recommend that this difference be a minimum of 25℃. To measure oil temperature through the compressor shell, place a thermocouple on the bottom center (not the side) of the compressor shell and insulate from the ambient.

During rapid system changes, such as defrost or ice harvest cycles, this temperature difference may drop rapidly for a short period of time. When the crankcase temperature difference falls below the recommended 25℃, our recommendation is the duration should not exceed a maximum (continuous) time period of two minutes and should not go lower than a 12℃ difference.

Screens

Screens with a mesh size finer than 30 x 30(0.6mm openings) should not be used anywhere in the system with these compressors.

Crankcase Heaters

- Single-phase

  No crankcase heaters are required on single-phase scroll compressors.
- Three-phase - outdoor only

  Crankcase heaters are required on three phase compressors where the system charge exceeds 5kg.

Discharge Line Thermostat

A discharge line thermostat is required in the compressor control circuit. The thermostats have a cut out setting that will insure discharge line temperatures below the 125℃ maximum limit. It should be installed approximately 160mm from the discharge tube outlet. If a service valve is installed at the discharge tube, the thermostat should be located 130mm from the valve braze. For proper functioning in extremely low outdoor ambient conditions, it is recommended the thermostat should be insulated to protect it from a direct air stream.

Pressure Controls

Both high and low-pressure switches are required on the compressors. The suggested cut out settings see table 2 below.

Control Type	R404A	R22
Low	3 PSIG min.	0 PSIG min.
High	450 PSIG max.	400 PSIG max

Table 2 high and low pressure switches setting

Pump Down Recommendations

Refrigeration scroll compressors use a low-leak discharge valve to prevent high-pressure backflow into the low side. Typically, this check valve prevents system pressures from equalizing and pump down can be achieved. If short cycling cannot be avoided, using a 3-minute time delay will limit the cycling of the compressor to an acceptable level.

IPR Valve

Invotech refrigeration scroll compressors have internal pressure relief valves, which open at a discharge to suction differential pressure of 375 to 450 psi. This action will trip the motor protector and remove the motor from the line.

Motor Protection

Conventional inherent internal line break motor protection is provided.

Oil Types

Polyol ester lubricants must be provided for the YM**E scroll compressor is to be used with HFC refrigerants. YM**A compressors are intended for use with R22 and are supplied with mineral oil.

POE must be handled carefully and the proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. POE must not come into contact with any surface or material that might be harmed by POE, including without limitation, certain polymers (e.g. PVC/CPVC and polycarbonate).

The system with POE oil should not be open to the air more than 3 minutes. Don’t remove the suction/discharge plugs until the compressor is ready to braze.

Oil Charges

The initial oil charge is 1.4L, the re-charge volume is 1.25L.

Oil Management for Rack Applications

Invotech Scroll refrigeration compressors may be used on multiple compressor parallel rack applications. This requires the use of an oil management system to maintain proper oil level in each compressor crankcase. The sight glass connection supplied can accommodate the mounting of the oil control devices.

Unlike semi-hermetic compressors, scroll compressors do not have an oil pump with accompanying oil pressure safety controls. Therefore, an external oil level control is required.

Compressor Tubing and Mounting

Compressor mounting must be selected based on application. Consideration must be given to sound reduction and tubing reliability. Some tubing geometry or “shock loops, may be required to reduce vibration transferred from the compressor to external tubing.

Mounting for Rack Systems - Specially designed rubber grommets are available for Invotech Scroll 2-6 HP scroll rack applications. These grommets are formulated from a high durometer material specifically designed for refrigeration applications. The high durometer limits the compressors motion thereby minimizing potential problems of excessive tubing stress. Sufficient isolation is provided to prevent vibration from being transmitted to the mounting structure. This mounting arrangement is recommended for multiple compressor rack installations.

Mounting for Rack Systems

The use of standard soft grommets is not recommended for most refrigeration scroll rack installations. These softer mounts allow for excessive movement that will result in tube breakage, unless the entire system is properly designed.

Tubing Considerations

Proper tube design must be taken into consideration when designing the tubing connecting the scroll to the remaining system. The tubing should provide enough “flexibility” to allow normal starting and stopping of the compressor without exerting excessive stress on the tube joints. In addition, it is desirable to design tubing with a natural frequency away from the normal running frequency of the compressor. Failure to do this can result in tube resonance and unacceptable tubing life. Figure 5 shows examples of acceptable tubing configurations.

The examples are intended only as guidelines to depict the need for flexibility in tube designs. In order to properly determine if a design is appropriate for a given application, samples should be tested and evaluated for stress under various conditions of use including voltage, frequency, and load fluctuations, and shipping vibration. The guidelines above may be helpful; however, testing should be performed for each system designed.

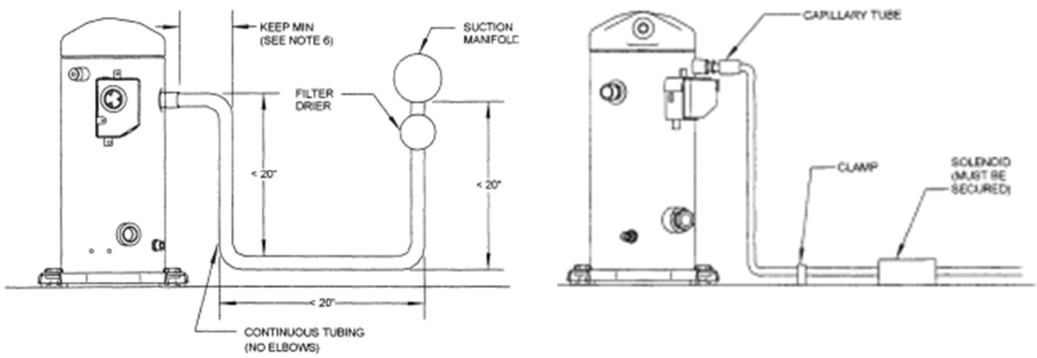


Figure 5 Typically Suction Line and Injection Line Arrangements

Notes: The above tubing configurations are guidelines to minimize tube stress

Follow similar guidelines for discharge tubing and oil return tubing as needed.

If a run of over 500mm is required, intermediate clamps may be necessary.

Do not hang weights on tubing (e.g. filter drier on suction tubing) except after clamps or close to the header.
Tube runs of less than 200mm is not recommended.
This dimension should be made as short as possible (e.g. 50mm or less) but still insuring a proper braze joint.
The above tubing recommendations are based on “no elbow joints”. The use of continuous tubing is preferred.

Fusite

Fusite pin orientation for single-phase and three-phase refrigeration scroll compressors are shown in Figure 6 and inside the terminal box.

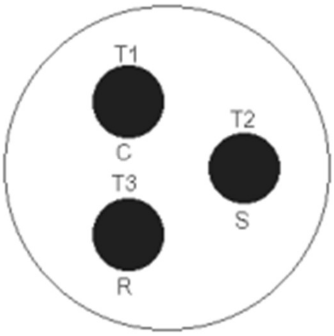


Figure 6 Motor terminal connections

Shell Temperature

System component failure may cause the top shell and discharge line to briefly reach temperatures above 150℃. Wiring or other materials, which could be damaged by these temperatures, should not come in contact with the shell.

Connection Fittings

Scroll compressors are provided with either braze connections or Rotalock adapters depending on the bill of material selected.

All YF models have copper plated steel suction and discharge fittings for a more rugged, leak resistant connection.

See section on New Installation (see Figure 9) for suggestions on how to properly braze these fittings.

Three-Phase Rotation Direction

Scroll compressors are directional dependent: i.e., they will compress in one rotational direction only. On single phase compressors, this is not an issue since they will only start and run in the proper direction (except as described in the Labeled Brief Power Interruptions). Three-phase scrolls, however, will rotate in either direction depending on the power of the phasing. So there is a 50/50 chance of connected power being “backwards.” Contractors should be warned of this. Appropriate instructions or notices should be provided by the Original Equipment Manufacturer.

Verification of proper rotation can be made by observing that the suction pressure drops and the discharge pressure rises when the compressor is energized. Additionally, if operated in reverse the compressor is noisier and its current draw is substantially reduced compared to tabulated values.

Although operation of scroll in reverse direction for brief periods of time is not harmful, continued operation could result in failure.

All three-phase compressors are wired identically internally. Once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the same fusite terminals will maintain the proper rotation.

Brief Power Interruptions

Brief power interruptions (less than 0.5 second) may result in powered reverse rotation of single-phase refrigeration scroll compressors. High-pressure discharge gas expands backward through the scrolls at power interruption causing the scroll to orbit in the reverse direction. If power is reapplied while this reversal is occurring, the compressor may continue to run noisily in the reverse direction for several minutes until the compressor internal protector trips. This has no negative effect on durability. When the protector resets, the compressor will start and run normally.

Invotech recommend the use of a timer which can sense brief power interruptions and lock the compressor out of operation for two minutes. A typical timer circuit is shown in Figure 7.

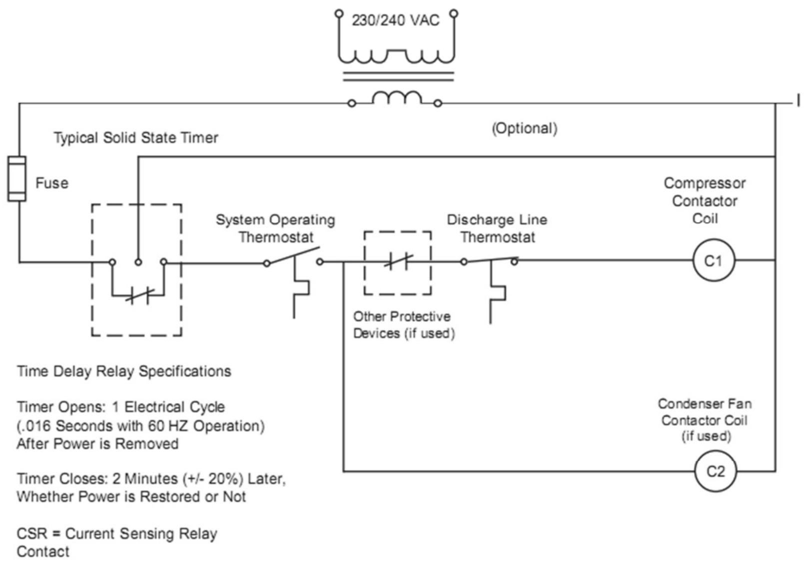


Figure 7 Wiring Schematic

No time delay is required on three phase models to prevent reverse rotation due to power interruptions

Deep Vacuum Operation

Do not run a refrigeration scroll compressor in a vacuum. Failure to heed this advice can result in permanent damage to the compressor.

A low-pressure control is required for protection against vacuum operation. See the section on pressure controls for the proper set points.

Scroll compressors (as with any refrigeration compressor) should never be used to evacuate refrigeration or air conditioning systems.

System Evacuation

An important step in effectively cleaning a system before operation is proper evacuation. Air is very detrimental to refrigeration systems and must be removed before start up and after field service. Blowing out lines with dry nitrogen may remove a major part of the air from a system, but if air is trapped in the compressor during installation it is practically impossible to remove from the compressor crankcase by purging with nitrogen.

New compressors are shipped with a dry air holding charge, and must be evacuated before being put in the system.

Triple evacuation of the system or compressor, as required, is strongly recommended (twice to 1500 microns and finally to 500 microns), breaking the vacuum each time with 30 PSIG dry nitrogen. The vacuum pump must be connected to both the high and low sides of the system through properly sized coactions, since restrictive service connections may make the process so slow as to be unacceptable, or may lead to false readings because of pressure drop through the fittings.

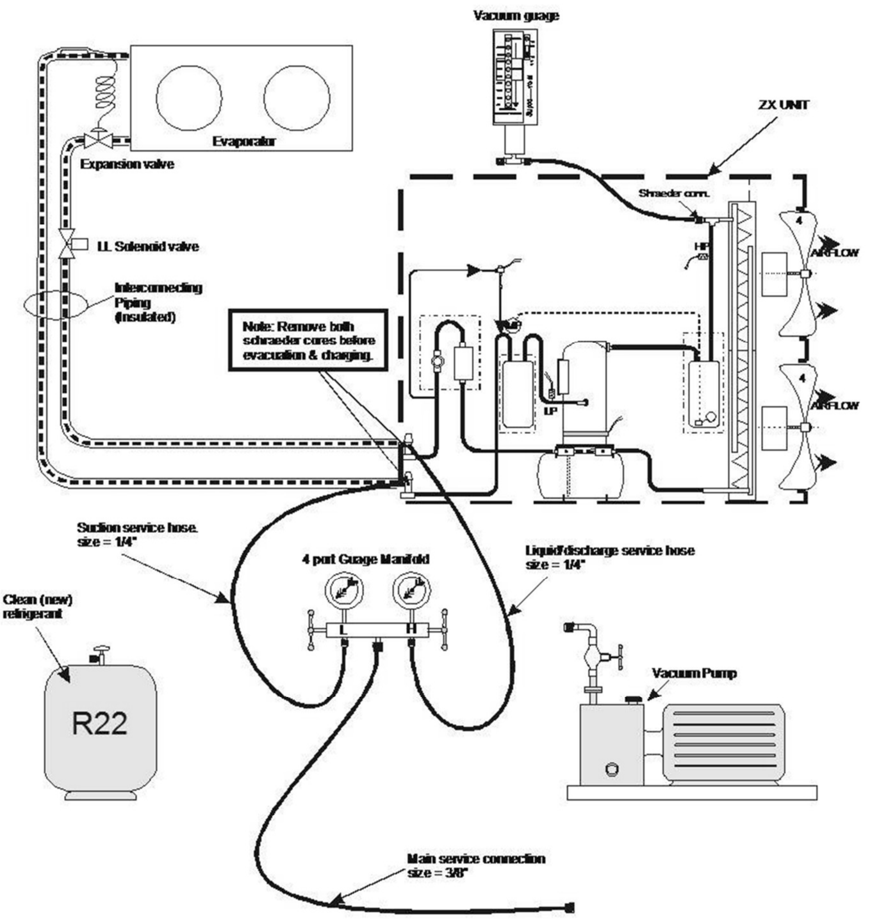


Figure 8 System Vacuum and Charging Connection Schematic

Charging Process

Do not power on the compressor before charging refrigerant.

Use the scale to control charge quantity. One liquid drier is recommended to connect between refrigerant cylinder and manifold to prevent moisture into system during charging. Connect refrigerant cylinder to both high and low side of the refrigeration system, power on the solenoid valve if possible (do not power on the compressor at this time). Invert refrigerant cylinder if needed to ensure only liquid can be charged into both high and low sides. Charge the refrigerant to the system as much as needed (at least 70% of total needed). Disconnected the high side charge port, turn on the compressor, and continue charge the liquid from the low side until the refrigerant is enough for the system.

Never close the suction service valve when compressor is running.

Unbrazing System Components

If the refrigerant charge is removed from a scroll unit by bleeding the high side only, it is sometimes possible for the scrolls to seal, preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized. If a brazing torch is then applied to the low side, the pressurized refrigerant and oil mixture could ignite as it escapes and contacts the brazing flame. It is important to check both the high and low sides with manifold gauges before un-brazing. In the case of an assembly line repair, remove the refrigerant from both the high and low sides. Instructions should be provided in appropriate product literatures and assembly areas.

High Potential (Hi-pot) Testing

Invotech scroll compressors are configured with the motor below the compressor. As a result when liquid refrigerant is within the compressor shell the motor can be immersed in liquid refrigerant to a greater extent than with compressors with the motor mounted above the compressor. When compressors are Hi-pot tested and liquid refrigerant is in the shell, they can show higher levels of leakage current than compressors with the motor on top because of the higher electrical conductivity of liquid refrigerant than refrigerant vapor and oil. This phenomenon can occur with any compressor when the motor is immersed in refrigerant. The level of current leakage does not present any safety issue. To lower the current leakage reading the system should be operated for a brief period of time to redistribute the refrigerant to a more normal configuration and the system Hi-pot tested again. Under no circumstances should the Hi-pot or Meg-ohm test be performed while the compressor is under a vacuum.

Invotech Scroll Functional Check

Refrigeration scroll compressors do not have internal suction valves. It is not necessary to perform functional compressor tests to check how low the compressor will pull suction pressure. This type of test may damage a scroll compressor. The following diagnostic procedure should be used to evaluate whether an Invotech Scroll compressor is functioning properly.

1. Verify proper unit voltage.
2. Normal motor winding continuity and short to ground checks will determine if the inherent overload motor protector has opened or if an internal short to ground has developed. If the protector has opened, the compressor must cool sufficiently to reset.
3. With service gauges connected to suction and discharge pressure fittings, turn on the compressor. If suction pressure falls below normal levels, the system is either low on charge or there is a flow blockage.

4a. Single-Phase Compressors

If the suction pressure does not drop and the discharge pressure does not raise to normal levels the compressor is faulty.

4b. Three-Phase Compressors

If the suction pressure does not drop and the discharge pressure does not rise, reverse any two of the compressor power leads and reapply power to make sure the compressor was not wired to run in the reverse direction.

The compressor current draw must be compared to published compressor performance curves at the compressor operating conditions (pressures and voltages). Significant deviations ($\pm 15^{0}$/o) from published values may indicate a faulty compressor.

New Installation

- The copper-coated steel suction, discharge, and injection tubes on scroll compressors can be brazed in approximately the same manner as any copper tube.
- Recommended brazing material - Any Silfos material is recommended, preferably with a minimum of 5% silver. However, 0% silver is acceptable.
- Use of a dry nitrogen purge to eliminate possibility of carbon buildup on internal tube surfaces is recommended.
- Be sure process tube fitting I.D. and process tube O.D. are clean prior to assembly.
- Remove the discharge plug at first, then remove the suction plug.
- Apply heat in Area 1. As tube approaches brazing temperature, move torch flame to Area 2.
- Heat Area 2 until braze temperature is attained, moving torch up and down and rotating around tube as necessary to heat tube evenly. Add braze material to the joint while moving torch around circumference.
- After braze material flows around joint, move torch to heat Area 3. This will draw the braze material down into the joint. The time spent heating Area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

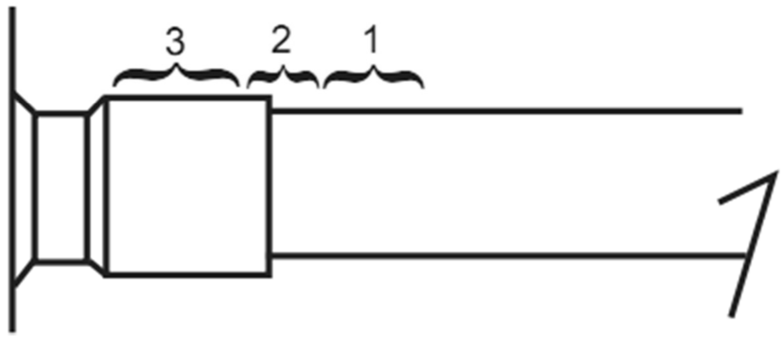


Figure 9 Scroll tubing Brazing

Field Service To Disconnect:

- Recover refrigerant from both the high and low side of the system. Cut tubing near compressor.

To reconnect:

- Recommended brazing materials - Silfos with minimum 5% silver or silver braze material with flux.
- Reinsert tubing fitting.
- Heat tube uniformly in Area 1, moving slowly to Area 2. When joint reaches brazing temperature, apply brazing material.
- Heat joint uniformly around the circumference to flow braze material completely around the joint.
- Slowly move torch in Area 3 to draw braze material into the joint.
- Do not overheat joint.

Vapor Injection

The refrigeration Economized Vapor Injection (EVI) compressor was developed to provide improved capacity and efficiency. EVI compressor systems benefit over standard refrigeration compressor systems of equivalent horsepower due to the following:

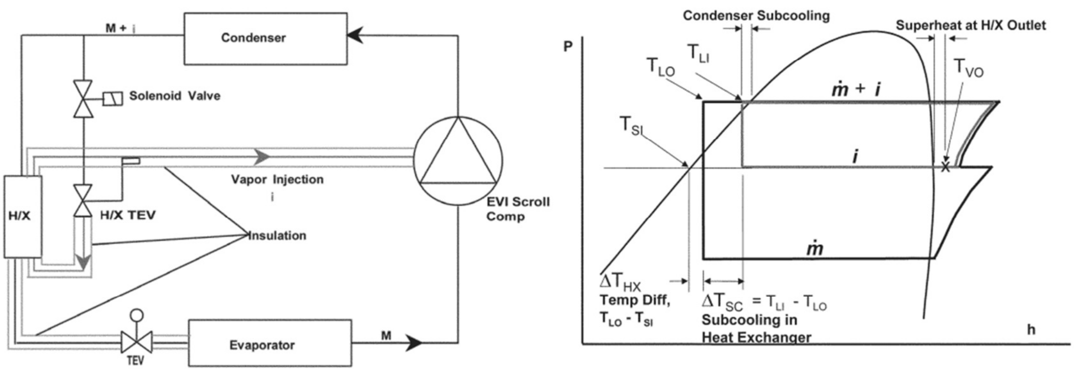
Capacity Improvement - The capacity is improved by increasing the h (change in enthalpy) in the system rather than increasing mass flow. This is accomplished without increasing compressor displacement.

Increased Energy Efficiency Ratio (EER) – The efficiency improves due to the fact that the gain in capacity is greater than the increase in power that the compressor consumes.

Cost and Energy Advantage - Because a smaller horsepower compressor can be used to achieve the same capacity as a larger horsepower compressor, there is an inherent cost advantage.

Theory of Operation

Invotech EVI scroll compressors are equipped with an injection connection for Economizer Operation. Economizing is accomplished by utilizing a sub-cooling circuit similar to that shown in Figure 1.



Definition(s)	Description
Tc	Condensing temperature
Tli	Liquid temperature entering H/X
Tlo	Subcooled liquid leaving H/X
Pi	Intermediate Pressure
Tsi	Saturated temperature at intermediate pressure
Tvo	Vapor temperature leaving H/X
Tvi	Vapor temperature entering H/X
Tsc	Liquid subcooling in H/X
M	Evaporator Mass Flow
I	Vapor Injection Mass Flow
ΔT_{HX}	Liquid temp out H/X-Liquid-Saturated temperature at intermediate pressure
ΔT_{SC}	Liquid temp in to H/X-subcooled liquid temp out H/X

Figure 1 Circuit Diagram and Cycle for EVI

This mode of operation increases the refrigeration capacity, and in turn, the efficiency of the system. The benefits provided will increase as the compression ratio increases, thus, more gains will be made in summer when increased capacity may actually be required.

The schematic shows a system configuration for the economizer cycle. A heat exchanger is used to provide sub-cooling to the refrigerant before it enters the evaporator. This sub-cooling process provides the increased capacity gain for the system, as described above. During the sub-cooling process a small amount of refrigerant is evaporated and superheated. This superheated refrigerant is then injected into the mid compression cycle of the scroll compressor and compressed to discharge pressure. This injected vapor also provides cooling at higher compression ratios, similar to liquid injection of standard YF Scroll compressors.

System Configuration for the Vapor Injection Application

There are two methods of controlling refrigerant flow at the heat exchanger - downstream and upstream extraction.

Downstream Extraction

In downstream extraction the TXV is placed between the liquid outlet and vapor inlet of the heat exchanger. The advantage of downstream extraction is that sub-cooling is ensured because the liquid is further sub-cooled as it flows through the heat exchanger. Therefore, more sub-cooled liquid enters the TXV which increases the probability that the valve will not hunt. The disadvantage with this method is that it is not as efficient as the upstream method; however, the difference is too small for practical purposes. See Figure 2a.

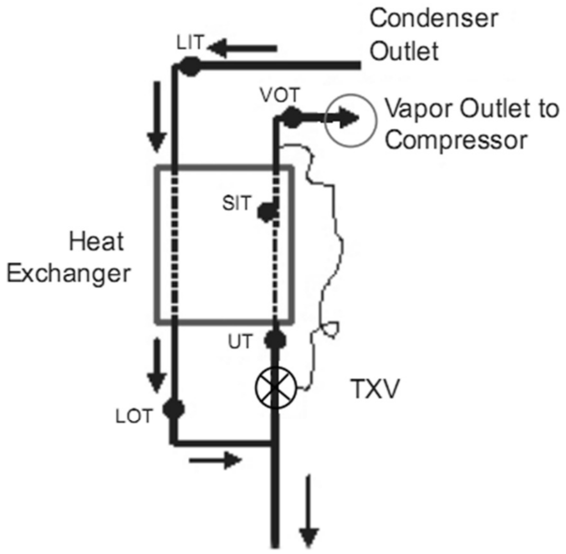


Figure 2a Downstream Extraction

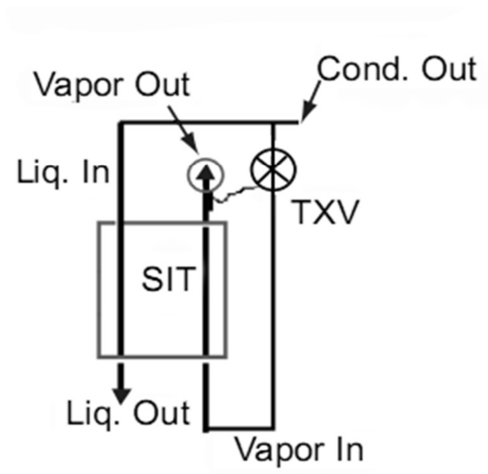


Figure 2b Upstream Extraction

Upstream Extraction

In upstream extraction the TXV is placed between the condenser and the heat exchanger. The TXV regulates the flow of sub-cooled refrigerant out of the condenser and into the heat exchanger. With this type of configuration there is a potential for flash gas which would cause the valve to hunt. See Figure 2b.

Heat Exchanger Piping Arrangements

Best sub-cooling effect is assured if counter flow of gas and liquid is provided as shown (see Figure 4). In order to guarantee optimum heat transfer, the plate heat exchanger should be mounted vertically and vapor should exit it at the top.

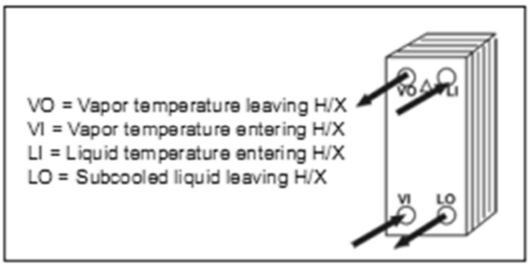
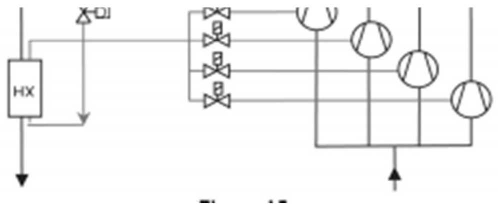


Figure 3 Plate Heat Exchanger Piping Arrangement

Multiple Compressor Applications

EVI can also be used in multiple compressor applications. Unlike a standard compressor system, the EVI compressor system changes its delivered capacity by changing the amount of sub-cooling provided at the sub-cooling heat exchanger. The result is that in high ambient temperature conditions (summer operation) and in low ambient temperature conditions (winter operation), the same number of compressors tend to run. It is important to note this since most personnel are used to seeing fewer compressors in operation in the cooler winter months compared to the hotter summer months; with EVI, almost the same number of compressors will be running in the summer and winter.

Multiple EVI compressors can be used with either a single heat exchanger for each compressor or a common heat exchanger for all compressors. In case of a common heat exchanger, a solenoid valve should be installed on each individual vapor injection line.



e heat exchanger and of the thermostatic expansion valve
refrigerant distribution is required in the common heat
return, even at part load.

ation (more than 2 compressors in parallel), the use of an
ifferent TXV(s) controlled by individual solenoid valves,
t 100% full load and the second solenoid valve for 30% of
ssary to ensure that the solenoid valves, vapor injection
er to keep pressure drop to a minimum. At the same time,
amounts of oil do not accumulate in the header.

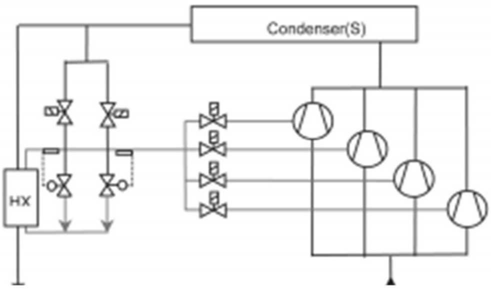


Figure 4a EVI Paralleling with HX TXV of different capacity

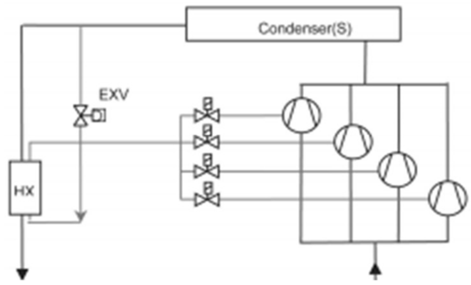


Figure 4b Paralleling with HX EXV

Controlling Liquid Out Temperature (LOT)

The LOT will typically be determined by the operating condition of the compressor. If the LOT needs to be fixed at any specific value (for example, 10℃) for purposes of good system control, an Evaporator Pressure Regulator (EPR) valve may be introduced at the vapor outlet of the sub-cooling heat exchanger.

Heat Exchanger Sizing

Heat exchangers should be sized so that adequate design margin for the entire range operation, but they should be optimized operating conditions. The parameters used to the proper heat exchanger size are described below:

SIT = Heat Exchanger saturated temperature at its outlet pressure.

LIT = Liquid in Temp (~Condensing Outlet)

LOT = Liquid Out Temp = SIT + TD

VIT = Vapor In Temp ~SIT + Loss

VOT = Vapor Out Temp = SIT + Superheat

H = Enthalpy

Sub-cooling = LIT - LOT

Superheat = VOT - SIT

TD = LOT- SI

Example of Heat Exchanger Sizing Optimized YF41E1G-V100 R404A

Step 1

- Know Condition -31.7/40.6/0/18.3℃ T_e/T_c / Cond. SC / Suct. RG

Step 2

- Determine Flow M_e 128kg/hr

Step 3

- Estimate SIT From Guideline -11.1℃
- Step 4
- Use the 5.6℃ Guidelines To Derive
- LIT = Tc – 5.6 =35℃
- LOT = SIT+ 5.6 =-5.5℃
- HX SC = LIT – LOT 40.5℃

- HX KJ/hr =M_e x (H_{LIT} - H_{LOT})
  =128 x (251.63 – 192.56)=7561KJ/Hr=2.1Kw

Example of Heat Exchanger Sizing Fixed Liquid Temperature YF41E1G-V100 R404A

Step 1

- Know Condition -31.7/40.6/0/18.3℃ T_e/T_c / Cond. SC / Suct. RG

Step 2

- Determine Flow Me 128kg/hr (50Hz)

Step 3

- Use the 5.6℃ Guidelines To Derive
- LIT = Tc – 5.6 35℃
- LOT user defined 10℃
- HX SC =LIT-LOT 25K
- HX =M_e X (H_{ft} – H_{lot}) = 128 X (251.63-214.4)=4766KJ/Hr=1.3Kw

= T◦ - 10° user defined =LIT - LO

The key parameter in determining the proper heat exchanger is the Saturated Injection Temperature (SIT). It is imperative the following procedure be followed for optimized performance. The SIT has been derived experimentally and can be approximated by the function SIT=0.44Te+0.28Tc-11.67(℃). After determining the SIT, a 5.6℃ Condenser Sub-cooling, TD, and Superheat are targeted. This is done in order to optimize system performance while at the same time maintaining system reliability and functionality. Once these parameters have been established, the heat exchanger capacity can be established, which gives the required heat exchanger size.

For multiple compressor applications the same process can be used to determine the heat exchanger size needed by adding together the individual heat exchanger capacities for each compressor.

Line Sizing

In single compressor applications, the vapor injection line from the heat exchanger to the compressor should be 3/8" - 1/2" and kept as short as possible in order to minimize pressure drop loss. The liquid line from the heat exchanger to the evaporator should be insulated and kept as short as possible in order to maximize the sub-cooling at the evaporator. If a vapor injection header is used, the header diameter should be such that the cross-sectional area is equal to the sum of the cross sectional areas of the individual cross-sectional lines to the compressor.

For example, for four compressors, each with a 3/8" vapor injection line, the header tube diameter should be a 7/8" tube. In addition, the individual injection lines to the compressors should tap into the header either on top or on the sides of the header tube; a bottom tap will increase the risk of returning liquid into the compressor through the vapor injection line.

Heat Exchanger TXV Sizing

TXV's should be sized so that they have adequate design margin for the entire range of system operation, but they should be optimized for normal operating conditions. Select a TXV that is able to handle the capacity of the heat exchanger determined in the section above.

Solenoid Valve & Ball Valve

A solenoid valve is required to stop the flow of vapor from the system to the compressor when the compressor is in the off cycle. This must be a vapor solenoid sized equivalent to or larger than the vapor injection tube size. For service purposes, a mechanical ball valve is also recommended in the vapor injection line.

Current Sensing Relay

To prevent the solenoid from remaining open during a "motor protector trip" a current sensing relay must be provided that senses whenever the compressor is "off" and closes the solenoid to stop injection.