

# Application Guidelines for Invotech YH

## High Efficiency Scroll Compressors for Air Conditioning

### **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 YH Invotech Scroll™ compressor represents the latest generation of compliant scroll technology for the air conditioning and heat pump industry. YH Scroll compressors are special designed for the high temperature applications.

## Nomenclature

The YH scroll model numbers include the nominal refrigeration capacity at standard 50HZ ARI rating conditions for high temperature (7.2/54.4°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](http://www.invotech.cn).

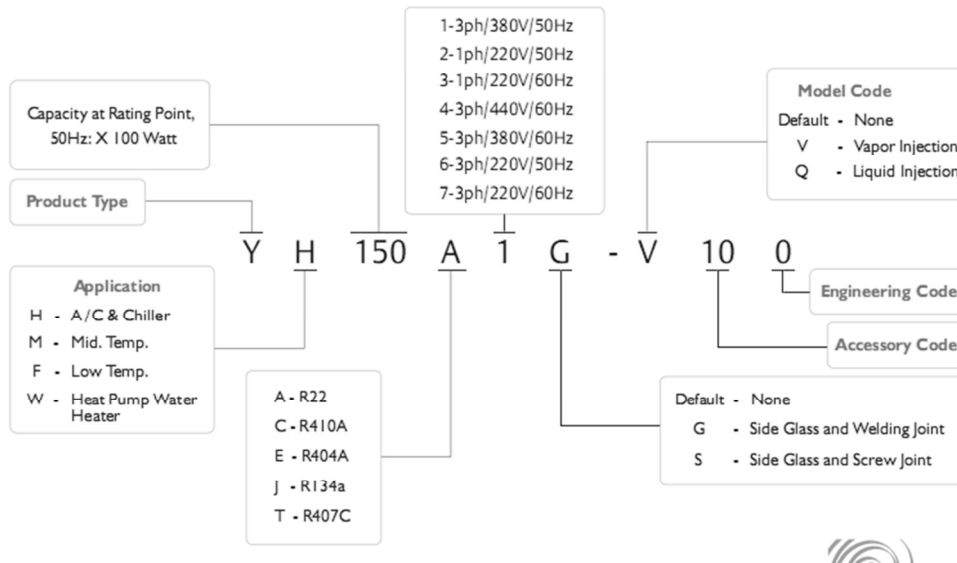


Figure 1 YH Nomenclature

## Operating Envelope

The YH refrigeration scroll compressor models can be used with R22 or R407C refrigerants depending on the model selected and the lubricant used.

The YH\*\*A and YH\*\*T models are intended for high temperature refrigeration type duty. The approved operating envelopes for these models are such that they are ideally suited for applications such as room air conditioning, heat pump, chiller, etc. The models and operating envelopes are depicted in Figures 2.

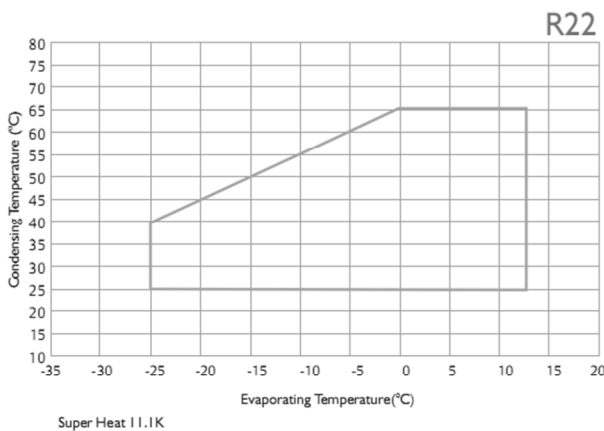


Figure 2a

YH\*\*A Application Envelope for R22

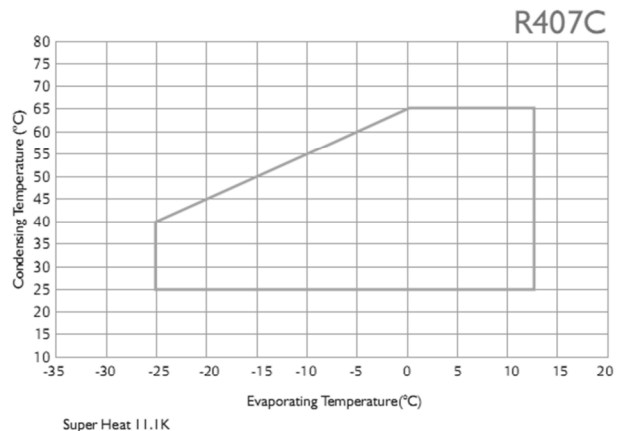


Figure 2b

YH\*\*T Application Envelope for R407C

## 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 5K 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°C. 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 cycles, this temperature difference may drop rapidly for a short period of time. When the crankcase temperature difference falls below the recommended 25°C, our recommendation is the duration should not exceed a maximum (continuous) time period of two minutes and should not go lower than a 12°C difference.

## Excessive Liquid Flood back Tests

The following tests are for those system configurations and charge over the limitation that need special testing to verify exemption from need of an accumulator. Figure 3 should be used to determine the effectiveness of an accumulator. The compressor sump temperature during any test where the return gas superheat is near zero must always meet the guidelines of Figure 3.

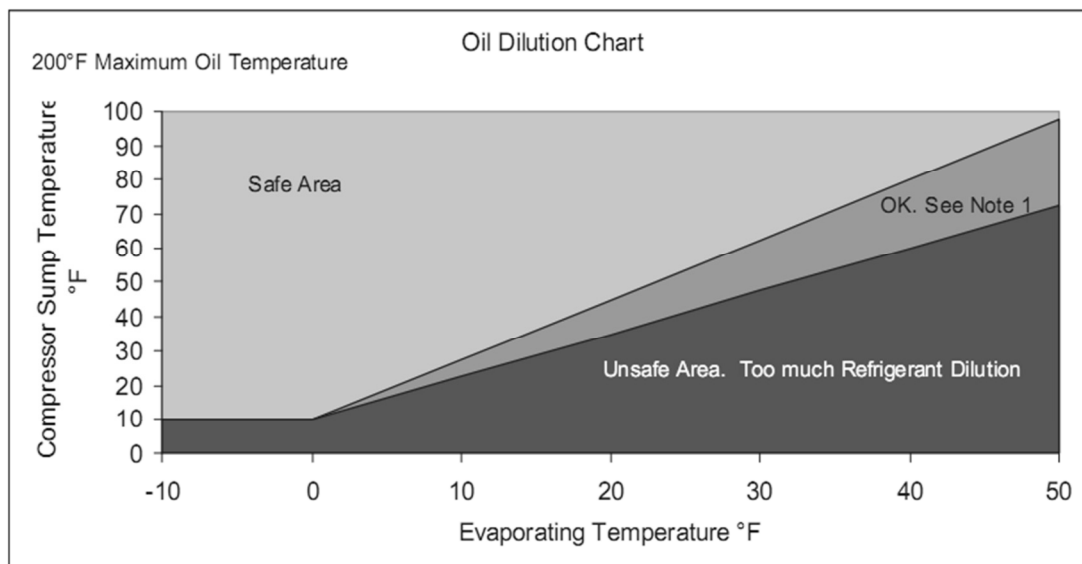


Figure 3

**Note1:** Operation in this refrigerant dilution area is safe in air to air heat pump heating mode. For other applications, such as AC only, review expansion device to raise superheat. A cold sump may result in high refrigerant migration after shut down.

To test for excessive continuous liquid refrigerant flood back, it is necessary to operate the system in a test room at conditions where steady state flood back may occur (low ambient heating operation).

Thermocouples should be attached with glue or solder to the center of the bottom shell and to the suction and discharge lines approximately 6 inches (15 cm from the shell). These thermocouples should be insulated from the ambient air to be able to record true shell and line temperatures. If the system is designed to be field charged, it should be overcharged by 15% in this test to simulate overcharging commonly found in field installations.

The system should be operated at an indoor temperature of 21 °C, and outdoor temperature extremes -18 °C (or lower in heating) to produce flood back conditions. The compressor suction and discharge pressures and temperatures as well as the sump temperature should be recorded. The system should be allowed to frost up for several hours (disabling the defrost control and spraying water on the outdoor coil may be necessary) to cause the saturated suction temperature to fall to below -23 °C. The compressor sump temperature must remain above the sump temperature shown in Figure 3 or design changes must be made to reduce the amount of flood back. If an accumulator is used, an oil return orifice size of 0.040 -0.055" (1 - 1.4 mm) is recommended. Increasing indoor coil volume, increasing outdoor air flow, reducing refrigerant charge, decreasing capillary or orifice diameter, and adding a charge compensator can also be used to reduce excessive continuous liquid refrigerant flood back.

To test for repeated excessive liquid flood back during normal system off-cycles perform the "Field Application Test". Operate the system as it would be operated in an actual field installation, cycling the unit on and off for the times indicated at each ambient. Obtain a sample compressor with a side sight tube to measure liquid level in the compressor. Set the system up in a configuration with the indoor unit elevated several feet above the outdoor unit with twenty-five feet (8 meters) of connecting tubing with no traps between the indoor and outdoor units. If the system is designed to be field charged, the system should be overcharged by 15% in this test to simulate overcharging commonly found in field installations. Operate the system in the cooling mode at the outdoor ambient, on/off cycle times, and number of cycles specified in Table 1. Record the height of the liquid in the compressor at the start of each on cycle, any protector trips, or any compressor stalls during each test. The criteria for pass/fail is whether the liquid level reaches the height of the scroll compressor suction fitting on the side of the shell. Liquid levels higher than the suction fitting will allow compressor oil floating on top of the refrigerant to be ingested by the scrolls and pumped out of the compressor.

Outdoor Ambient	29 °C	35 °C	40 °C
System On-Time (Minutes)	7	14	54
System Off-Time (Minutes)	13	8	6
Number of On/Off Cycles	5	5	4

Table 1 Field Application Test

### 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

Operation above or on the left of the operation envelope can cause high compression ratios or excessive internal compressor temperatures. This will result in overheating the scrolls, causing excessive wear resulting in premature compressor failure.

If the system is designed where operation cannot guarantee to operate inside the operation envelope, then the discharge line thermostat is required in the compressor control circuit. The cut out setting for the discharge line thermostat is 125 °C, it should be installed approximately 170mm from the discharge tube outlet, or approximately 130mm from the valve outlet port.

### Low Ambient Cut-Out

A low ambient cut-out is not required to limit air-to-air heat pump operation. Air-to-water heat pumps must

be reviewed since this configuration could possibly run outside of the approved operating envelope (Figure 5) causing overheating or excessive wear.

**Pressure Controls**

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

Control Type	R407C	R22
Low	12 PSIG min.	12 PSIG min.
High	400 PSIG max.	400 PSIG max

Table 2 high and low pressure switches setting

**Pump Down Recommendations**

A pump down cycle for control of refrigerant migration is not recommended for scroll compressors of this size. If a pump down cycle is used, a separate external check valve is suggested to be added.

**Air Conditioning System Suction Line Noise and Vibration**

Invotech Scroll compressors inherently have low sound and vibration characteristics. However, the sound and vibration characteristics differ in some respects from those of reciprocating compressors. In rare instances, these could result in unexpected sound complaints.

One difference is that the vibration characteristic of the scroll compressor, although low, includes two very close frequencies, one of which is normally isolated from the shell by the suspension of an internally suspended compressor. These frequencies, which are present in all compressors, may result in a low level “beat” frequency that may be detected as noise coming along the suction line into a house under some conditions. Elimination of the “beat” can be achieved by attenuating either of the contributing frequencies. The most important frequencies to avoid are line and twice-line frequencies for single-phase compressors and line frequency for three phase compressors. This is easily done by using one of the common combinations of design configurations described in Table 2. The scroll compressor makes both a rocking and torsional motion, and enough flexibility must be provided in the line to prevent vibration transmission into any lines attached to the unit. In a split system the most important goal is to ensure minimal vibration in all directions at the service valve to avoid transmitting vibrations to the structure to which the lines are fastened.

A second difference of the Invotech Scroll is that under some conditions the normal rotational starting motion of the compressor can transmit an “impact” noise along the suction line. This may be particularly pronounced in three-phase models due to their inherently higher starting torque. This phenomenon, like the one described previously, also results from the lack of internal suspension, and can be easily avoided by using standard suction line isolation techniques as described in Table 3.

The sound phenomena described above are not usually associated with heat pump systems because of the isolation and attenuation provided by the reversing valve and tubing bends.

Recommended Configuration	
Component	Description
Tubing Configuration	Shock loop
Service Valve	“Angled valve” fastened to unit
Suction muffler	Not required
Alternate Configuration	
Component	Description
Tubing Configuration	Shock loop
Service Valve	“Straight through” valve not fastened to unit
Suction muffler	May be required (Acts as dampening mass)

Table 3 recommended configuration

### **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.

### **Tandem Scroll Compressors**

A three-phase unit with a charge over 5kg must have crankcase heaters added to both compressors. Tighten to 14 NM for the bolts mounting the compressor on the rail. Holes in the mounting rails may be used to mount isolation grommets under the entire tandem.

A discharge check valve must be placed in the common discharge line when pump down is used. Both compressors must be at the same level to prevent oil from migrating to the lowest compressor through the oil equalization line.

Compressors may be individually cycled. Individual compressors should not be replaced in the field. The entire tandem compressor unit must be replaced if it becomes necessary to replace one compressor. Individual compressors configured for tandem usage may not be available for field replacement.

### **Mounting**

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.

Condensing Unit Mounting, for Invotech YM refrigeration scroll condensing unit applications, soft mounts are recommended.

### **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 4 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.

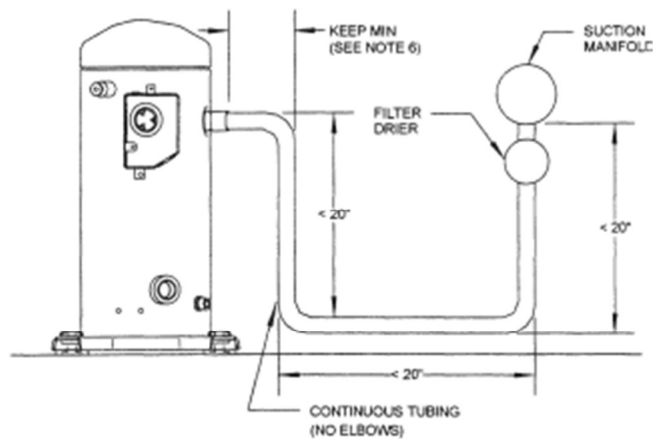


Figure 4 Typically Suction Line Arrangements

- 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 5 and inside the terminal box.

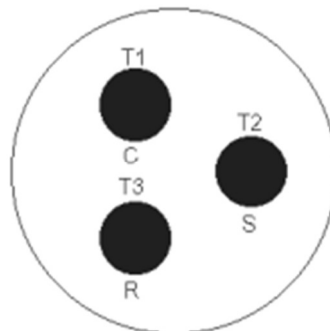


Figure 5 Motor terminal connections

## **Electrical Connection**

The orientation of the electrical connections on the Scroll compressors is shown in Figure 4. Three electrical connection options are available for these compressors. These include the “Molded Plug” one piece push-on connection, available in certain markets, and “Quick Connect” flag termination available on all scrolls of this size.

## **Shell Temperature**

System component failure may cause the top shell and discharge line to briefly reach temperatures above 150°C. 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 roto-lock adapters depending on the bill of material selected.

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

See section on New Installation (see Figure 6) 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 6.



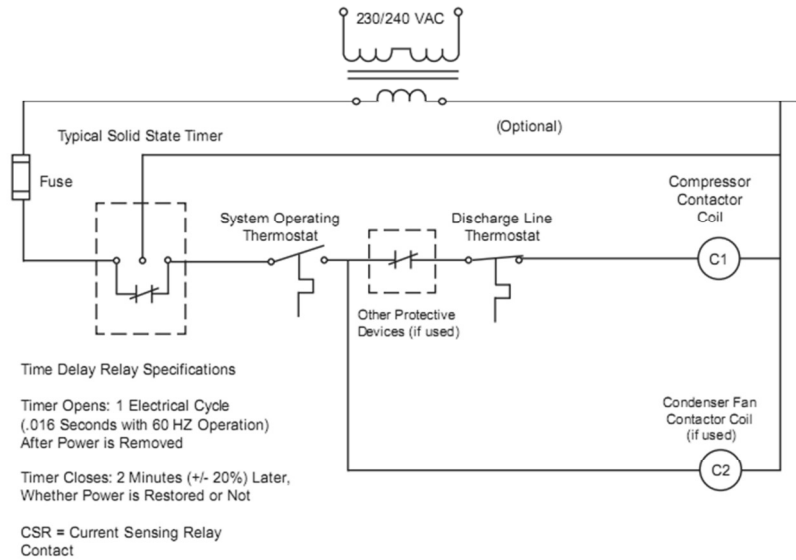


Figure 6 Wiring Schematic

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.

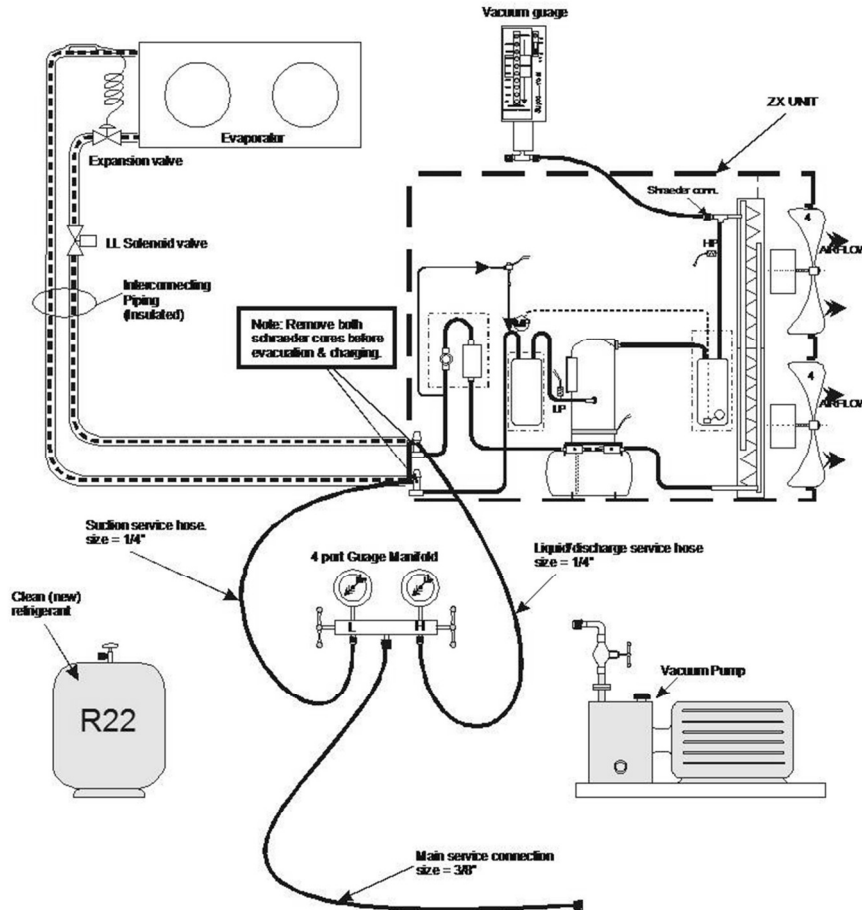


Figure 7 System Vacuum and Charging Connection Schematic

### 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). Disconnect 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 ( $\pm 15\%$ ) 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.

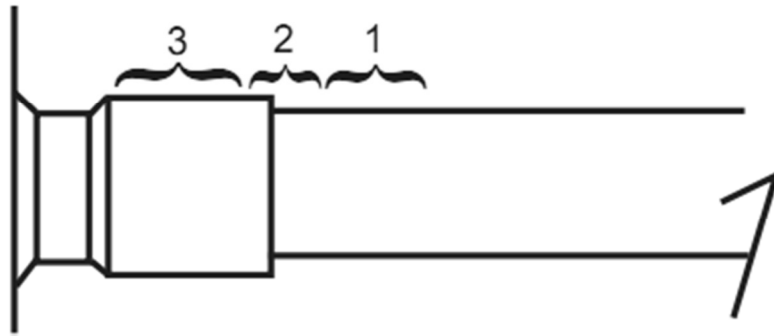


Figure 8 Scroll tubing Brazing

**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.

**Compressor Replacement after Motor Burn**

In the case of a motor burn, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through use of suction and liquid line filter dryers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. It is highly recommended that the suction accumulator be replaced if the system contains one. This is because the accumulator oil return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure.

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