

Suzhou Invotech Scroll Technology Co., Ltd.

IS-T-053

YW270C1G-V100 ~ YW400C1G-V100

**Series Low Ambient Temperature Heat
Pump Scroll Compressor User Manual**

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Safety Notice

The Invotech scroll compressors are designed and manufactured in accordance with relevant national standards. This safety notice applies to all Invotech scroll compressors.

It is recommended to keep this manual in a safe place. All maintenance or repair personnel shall access this manual easily, and they must follow the requirements of this safety notice and relevant local laws and regulations in related operations.

Safety Statement

- The refrigeration compressors should only be used for the proper applications.
- All installation, commissioning and maintenance personnel must hold the appropriate certificates (for air conditioning, HVAC or refrigeration related).
- All electrical connections must be made by the certified electrician.
- When installing, servicing, and maintaining electrical or cooling systems, all applicable laws and regulations must be strictly followed.

Electric Shock Risks

- All electrical circuits must be provided with appropriate fuses and circuit breakers.
- The power supply must be disconnected and locked before any service.
- All capacitors must be discharged before any service.
- The equipment must be grounded strictly in accordance with local laws and regulations.
- The electrically pre-insulated terminals must be used if required.
- The equipment manufacturer`s electrical wiring diagram must be always followed.
- All electrical connections must be made by the certified electrician.
- Any failure to follow these warnings may result in serious personal injury.

Pressurized System Risks

- The refrigeration system contains the refrigerant and refrigeration oil under a certain pressure.
- Before removing the compressor, the refrigerant must be collected from both high and low pressure sides and the internal pressure must be completely released, and confirmed with a pressure gauge.
- A suitable wrench must be used to remove or tighten the shut-off valve during maintenance.
- When the system is not charged or there is no pressure, or the shut-off valve is closed but the power supply is not locked, do not carry out any operation or leave it unattended until the system status is confirmed.
- Must use the correct refrigerant and refrigeration oil.
- Must take personal protective measures and wear personal protective equipment.
- Any failure to follow these warnings may result in serious personal injury.

Burning Risks

- Do not touch the compressor until it is cooled down.
- Ensure that all materials such as wires do not come into contact with hot areas on the compressor surface.
- Must take extreme cares when welding the system components.
- Must wear the personal protective equipment.
- Any failure to follow these warnings may result in serious personal injury or property damage.

Introduction

Invotech YW270C1G-V100~YW400C1G-V100 series scroll compressors adopt the compliance technology with vapor injection, which are designed for low ambient temperature heat pump applications. Under low ambient temperature heat pump conditions, it can effectively improve the system heating capacity and energy efficiency .

Nomenclature

In the naming of YW compressors, the numbers represents the cooling capacity (×100W) at 50Hz under the standard operating conditions of heat pump hot water (5/55°C). For more details, please contact Invotechsales representatives or log in the Invotech official website (www.invotech.cn) for inquiry.

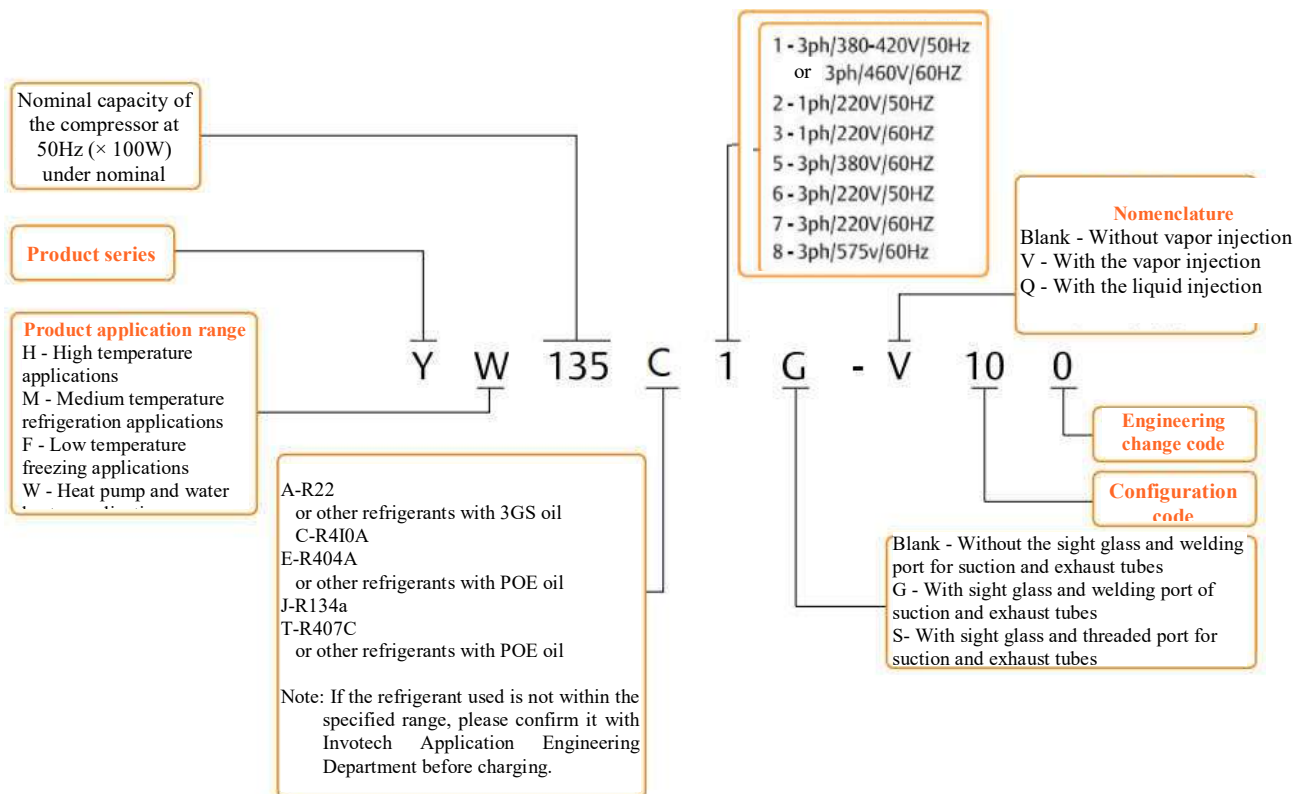


Fig. 1 Invotech compressor nomenclature

Operating Envelope

YW270C1G-V100~YW400C1G-V100 series scroll compressors are suitable for R410A refrigerant, with the application envelope as shown in Fig. 2.

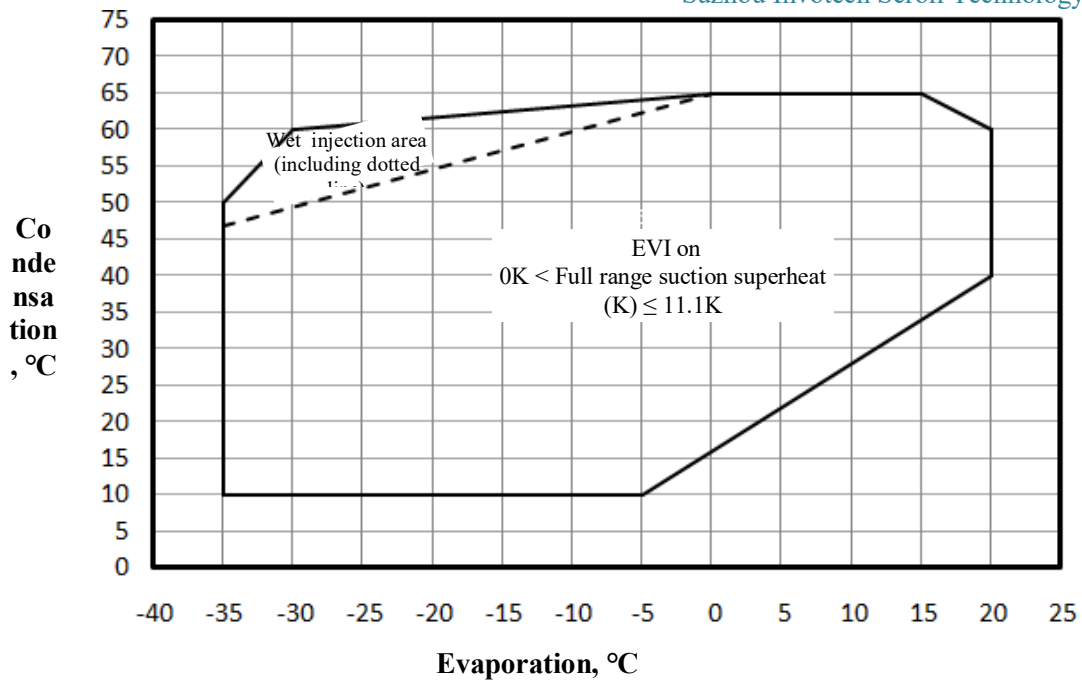


Fig. 2 Operating Envelope

System Design Recommendations and Application Notes

Tube Layout

The Invotech variable scroll compressors work with very low vibration, and in most applications, the vibration absorber are not required for the discharge and suction tubes. The suction and discharge tubes should be arranged as close as possible to the compressor body and there should be a part of tube parallel to the axial direction of the compressor, to absorb the torque when the compressor is tripped and shutdown.

Vibration absorbers or flexible fixings can be installed at the suction and discharge ports of the compressor, to prevent the compressor from transmitting vibration and noise through the tubes. The vibration absorbers should be arranged parallel to the axial direction of the compressor; when the diameter of the tubes is less than 12mm, a vibration isolation ring or vibration isolation glue can be applied in the tubes.

Design of height difference: if the evaporator is arranged under the compressor, the maximum height drop should not exceed 20m; if the evaporator is located higher than the compressor, the maximum height drop should not exceed 10m, the tubes should be arranged so as to avoid liquid refrigerant from flowing to the compressor.

Fix the vapor injection tube: Move the plate type heat exchanger (economizer) as close to the compressor as possible to avoid the increase of vibration caused by long tube (see Fig. 3).

When the economizer is arranged far away from the compressor, it is recommended to use the fixing method (Fig. 4), with which the copper tube should be fixed every 400mm to avoid excessive vibration.

For the rising suction tube, must pay attention to setting the oil flood back bend; set a U-shaped oil flood back bend at the bottom of the suction rising tube, and add an oil flood back bend every 5m (see Fig. 5).

All tubes must be kept clean and dry during storage and construction.

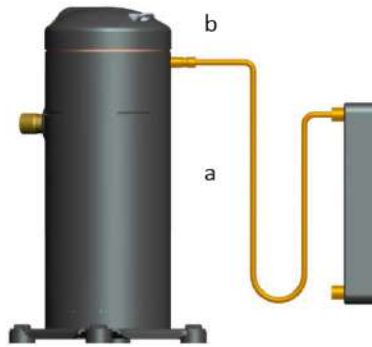


Fig. 3 Fix the vapor injection tube 1

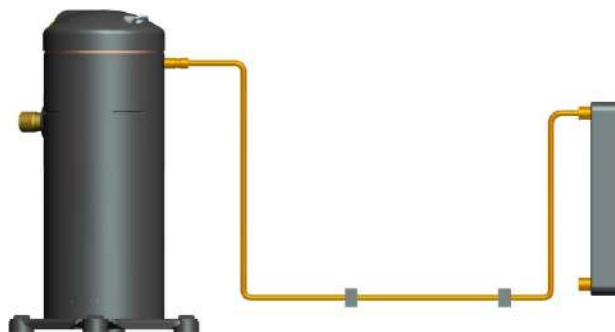


Fig. 4 Fix the vapor injection tube 2

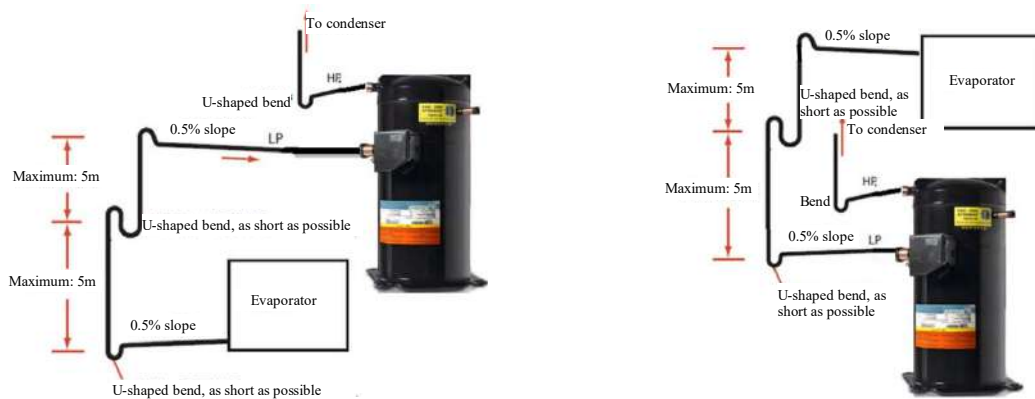


Fig. 5 Oil flood back bend setting

Notes:

The above tube arrangement is designed to minimize the stress on the tube.

The suction, discharge and oil flood back tubes can be designed with reference to Fig. 3.

Except for the positions immediately following the tube clamps or near the header, no heavy objects (such as the filter drier on the suction tube) shall be suspended on other tubes.

The length of the vertical tube at Position a should be not less than 200mm and not more than 400mm; the horizontal tube connected to the compressor port at Position b shall be as short as possible (such as, 50mm), but a sufficient length of the welding interface must be ensured.

It is not recommended to use a bent for the above tubes, and it is preferred to use a continuous long tube that has been bent and formed.

The intermediate pressure in the vapor injection circuit is a pulsation value. It can be considered to add a muffler on the vapor injection tube near the vertical tube close to the compressor to reduce the vibration caused by the pulsation of the intermediate pressure.

Tube Sizes

In order to ensure the smoothoil flood back, it is recommended that the flow rate in the horizontal suction tube is $\geq 4\text{m/s}$, and the flow rate in the vertical suction tube is $\geq 7\text{m/s}$.

Bending radius: Based on the process conditions, a larger bending radius should be chosen to avoid thinning of the outer wall thickness and wrinkling of the inner wall at the bend, and increase the flexibility of the tubes. The commonly used bending radius are shown in Table 1 (Unit: mm) as follows:

Table 1

Copper tube diameter	Φ5	Φ6	Φ7.94	Φ9.52	Φ12.7	Φ15.88	Φ19.1	Φ22	Φ28	Φ35
Bending radius R	15	15	20	25	25	30	35	45	60	70

The welding fit gap between copper tubes should be generally 0.03-0.13mm, and the fit length should be 8-10mm, so as to ensure the welding strength and welding performance of the joint.

Compressor connection tube: When the discharge and suction tubes are connected to the compressor, it is recommended to use the straight tube section with a length of about 50mm, to minimize stress concentration; the distance between the compressor and the vertical tube (parallel to the axial direction) must be more than 15mm.

Vibration reduction: The suction and discharge tubes of the compressor should be equipped with one or more U-shaped bends, to enhance the flexibility of the tubes and reduce the stress concentration. Moreover, avoid the same heights for each end of the U-shaped bend, and the bending radius of the U-shaped bend should not be less than 2 times of R.

Space between different parts:

- a) The distance among the tubes should be more than 10mm;
- b) I space between tubes and chassis should be more than 8mm,
- c) The distance between the tubes and the sharp object should be more than 20mm; the distance between the tube and the wire should be more than 15mm; the distance between the capillary tubes and the easily deformed tube should be more than 10mm.
- d) The assembly manufacturability and space for the whole tubes should be guaranteed.

Suction line accumulator.In the low temperature heat pump system, during the defrosting cycle or the transitional operation period, there may be uncontrollable, long-term, and a large amount of refrigerant liquid flood back. It is recommended to provide a suction line accumulator, withan effective volume of at least 50% system charging volume. The diameter of the oil flood back hole in the accumulator should be about 1.5mm for the compressors ranged from YW270***-YW400***, which should beverified by test, and the size of the filter screen should not be finer than 30*30 mesh.

Excessive liquid flood back or repeated flood back may dilute the refrigeration oil in the compressor, resulting in insufficient lubrication and bearing wear. The system should be designed properly to minimize the probability of liquid flood back and floodback and maximize the service life of the compressor.

In order to ensure that there is no liquid refrigerant flood back to the compressor during normal operation, a certain superheat must be ensured at the suction port of the compressor. It is recommended by the Invotech that the suction

superheat of the heat pump system is set at 3-5°C, i.e., the temperature measured on the suction tube at about 150mm away from the compressor suction port should be 3-5°C higher than the saturation temperature corresponding to the evaporation pressure, to prevent liquid flood back.

Another way to determine whether there is liquid refrigerant return to the compressor is to accurately measure the temperature difference between the compressor crankcase and the suction temperature. During normal operation, the advised temperature difference is shown in Fig. 6. The crankcase temperature can be measured as follows: Place a temperature sensor at the center of the compressor shell on the other side of the suction port and about 30mm to the bottom of the compressor, and the sensor should be well insulated to ensure that it is not affected by the ambient temperature.

When the system operating modes are switched quickly, such as defrosting, this temperature difference may drop rapidly in a short time period, when this temperature difference is lower than the recommended value, it is recommended that it is not more than 3 minutes, and the minimum temperature difference is not be less than 10K.

For heat pumps, it is most likely to cause the liquid flood back when the outdoor heat exchanger is frosted. Therefore, the defrosting test must be performed in an environment with an ambient temperature of 0°C and high humidity. The liquid flood back must be monitored when the reversing valve is operated, especially at the end of defrosting cycle.

Reversing Valve

The selected reversing valve must be tested to verify that it can be switched smoothly under various operating conditions.

It is recommended that the coil wiring method and control logic of reversing valve can ensure that it does not need for switching when the system reaches the set temperature and then is shut down under heating or cooling conditions. If the reversing valve is allowed for switching under shutdown status, due to instant reverse of the suction and discharge pressures in the compressor, the new pressure difference may cause the compressor scroll to be operated slowly under shutdown status until the pressure is equalized. This situation will not damage the compressor but it is possible to make noise when the compressor is shutdown.

Filter Screen

The filter screen is designed to protect the compressor, throttle parts or suction line accumulator from being blocked and disturbed by the dirt in the system during the operating process, so as to prevent damage to the compressor from the obstruction of the flow of oil or refrigerant in the compressor. The suction port of the compressor is equipped with a filter screen, and a filter with filter screen is required to be installed in front of all throttle components in the system. The recommended mesh size is 60-80 mesh; it is recommended to use 100 mesh in the packed units. The screen with a mesh of less than 30 x 30 mesh (0.6mm opening) should not be used anywhere in the system.

Crankcase Heater

In heat pump applications, it is recommended to use a crankcase heater. The recommended power of crankcase heater for YW270C1G-V100~YW400C1G-V100 should be 90W. The crankcase heater must be preheated in advance, and the preheating time should not be less than 12h before starting a new machine or restarting a machine after a long period of shutdown. In order to avoid unnecessary heating or excessive temperature rise in the crankcase, a temperature sensor may be arranged at the compressor crankcase and well insulated. The operation of the crankcase heater can be controlled with the temperature difference between crankcase temperature and the ambient temperature.

Oil Dilution and Compressor Cooling

The oil temperature curve is shown in Fig. 6, which can be used to judge the tolerance of the heat pump system to the liquid flood back when it is running. If the system is running and the oil temperature is close to the limit, the system

will be generally operated with a low efficiency.

At low ambient temperature, if the liquid flood back can be eliminated, the suction superheat temperature is around 3-5K, there will be relatively high heating capacity and energy efficiency of the heat pump system. The discharge temperature can be controlled by the vapor injection circuit. At this time, the oil temperature should be maintained in a safe area, which eliminates the damage to the compressor caused by the oil dilution, there will be no foam in the oil tank, and the oil amount will be reduced. It should be especially noted that at the end of defrost cycle, it is necessary to control the production of a large amount of fluid backflow, because the fluid flood back will dilute the oil, the compressor will immediately be switched to the heating mode, and the increased load on the bearing requires good lubrication conditions.

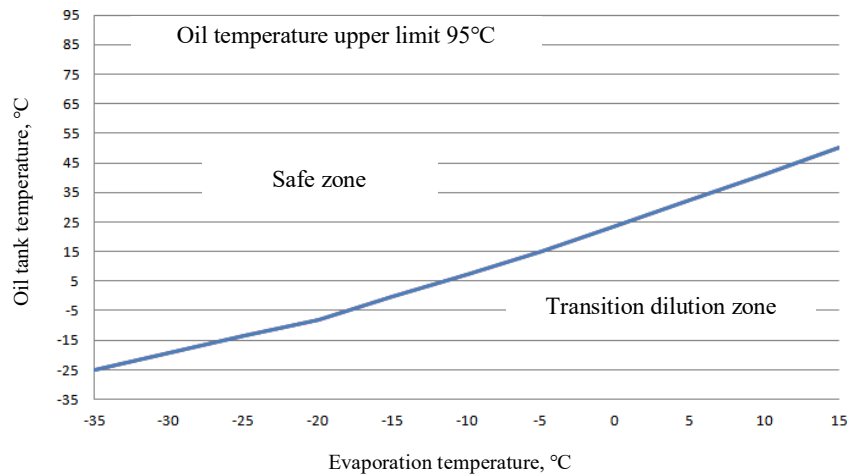


Fig. 6 Oil dilution curve

Discharge tube Temperature Protection

When the compressor is operated beyond the limit on the left and top of the envelope, or when the vapor injection circuit is not functioned properly, it may cause an excessive compression ratio and relatively high internal temperatures; in this case, the scroll may be overheated and worn excessively and even the compressor may be damaged permanently. It is recommended to install a discharge tube temperature protection switch on the discharge tube, to cut off the compressor immediately when the discharge temperature exceeds 120°C.

The control circuit is used to shutdown the compressor. If the compressor is tripped by discharge tube temperature protection switch, it is necessary to set a minimum reset time (at least 10min is recommended); when the protection is repeated several times within a specific time, for example if it is repeated 3 or more times within 1h, please lock the compressor until all faults are eliminated. For the compressor with the welded port, the discharge temperature sensor should be arranged on the discharge tube at about 150mm away from the compressor discharge port; for the compressor with the threaded port and a valve, the discharge temperature sensor should be arranged on the discharge tube at about 120mm away from the outlet of the discharge valve.

The discharge temperature sensor must have well thermal insulation measures. In the service life of the machine, the service life of the insulation material should be more than that of the machine.

Excessive Limit of Outlet Water Temperature

When the hot water is produced with the heat pump system, the return water temperature may be set as a control

indicator. Due to various reasons, there may be a relatively large difference between the actual outlet water temperature and the return water temperature on site. Under the compressor operating conditions, the condensing temperature is often based on the outlet water temperature. In order to ensure that the compressor is operated within its allowable operating conditions, the equipment manufacturer should set the maximum allowable outlet water temperature corresponding to each ambient temperature in the control program. The condensing temperature corresponding to the maximum outlet water temperature allowed cannot exceed the maximum operating condensing temperature corresponding to the evaporating temperature under the ambient temperature. When the actual outlet water temperature is higher than the limit value, the system will automatically reduce the target water temperature, or shutdown the compressor and check whether the return water temperature is too high or the temperature difference of inlet and outlet water is too large.

Pressure Controller

The system should be equipped with a high pressure switch and a low pressure switch. The recommended cut-off settings are shown in Table 2.

Table 2 High/low pressure switch settings

Control type	R410A
Low pressure	1 bar(g) min.
High pressure	42 bar(g) max.

The high-pressure protection switch should be reset manually. If there is high-pressure protection, must find out the reason. It is not recommended to force a high pressure on the compressor to test the high pressure protection switch.

The low pressure protection switch can be used effectively protect the compressor from damage when the system is leaked or partially blocked. Do not short-circuit or shield the low-voltage switch under any cases. The suction pressure may be lower than 1bar(g) during defrosting process or when the machine is started at low water temperature and low ambient temperature. In order to avoid unnecessary false alarms, an additional low-pressure protection switch with a cutoff value of 0bar(g) can be added. 0bar(g) should be used as the low pressure protection value during defrosting process and within 30s after the start, and the low pressure protection switch must not be shielded, to avoid damage to the compressor due to system leakage or blockage caused by the vacuum running of the compressor.

Overcurrent Protection

It is recommended to set the external current protection value to the compressor's $MCC \times 0.95$, where MCC is the maximum continuous running current of the compressor.

Start-stop Limits

After the compressor is started, the minimum continuous running time should not be less than 3min, and the number of starts and stops within 1h should not exceed 6 times.

Shell Temperature

Any system components damages may increase the compressor head temperature and discharge tube temperature up to 150°C or higher for a short period of time. At this temperature, some wires or other materials will be damaged, therefore, in the design, somepart such as wires and tubes must avoid to contact the compressor shell or high-temperature tubes.

Built-in Pressure Relief Valve

The Invotech three-phase scroll compressors are equipped with built-in pressure relief valves. When the pressure difference between the high-pressure chamber and the low-pressure chamber in the compressor reaches its set value (3.97~4.31MPa), the valve will be operated, to release the pressure in the high-pressure chamber to the low-pressure chamber, and the gas from the high-pressure chamber will be sprayed onto the motor protector, to drive the motor protector to trip and shut down the compressor.

Motor Protector

This series of compressors are equipped with built-in motor protectors. When the load of the motor is too heavy, or the motor is cooled down insufficiently and then the motor may be overheated, the motor protector will be operated to trip and shut down the compressor. After the motor protector is tripped, it may take a quite long time to reset until the motor is cooled down sufficiently. To monitor whether the motor protector is tripped or not, a current sensor should be used in the control circuit and the power line of the compressor should pass through the current sensor. If the contactor is activated, but the current cannot be detected the current, it means that the built-in motor protector of the compressor is tripped, and required for further inspection.

Refrigeration Oil

YW***C1G-V100 compressors should be charged with POE oil.

More care must be taken when operating the compressors with POE oil and must wear necessary protective equipment (such as gloves, safety glasses, etc.). POE oil should not come into contact with surfaces and materials which may be damaged by it, such as polymers (e.g. PVC/CPVC, polycarbonate, etc.).

For systems with POE oil, the exposure time to the air should be no more than 10min. It is recommended to remove the plugs of suction, discharge and vapor injection ports from the compressor just before welding operation.

Oil Charging and System Flood Back

Please check the compressor nameplate for the initial oil charging volume for each type of compressor and the recommended recharging volume after oil drainage,

When the length of the connecting tube of the system is less than 20m and the refrigerant charging volume is less than 7.5kg, not additional oil is required to charge the system; if the length of the tube is more than 20m or the charging mass is more than 7.5kg, it is necessary to charge the oil appropriately. For appropriate additional oil charging volume, please contact Invotech Application Engineering Department.

The compressor needs a minimum continuous operation time to ensure the oil flood back. The minimum continuous operation time should be determined in the tests and the continuous operation time with a stable oil flood back under low ambient temperature conditions should prevail.

Operating Principle of Vapor Injection

The vapor injection operation can increase the heat exchange capacity in the system and improve the energy efficiency of the system, especially under low ambient temperature conditions. A typical operating schematic diagram is shown in Fig. 7 (in actual applications, the appropriate system solution should be based on the specific needs. This diagram is for design reference only, and may not be suitable for all system requirements. If necessary, please contact Invotech Application Engineering Department).

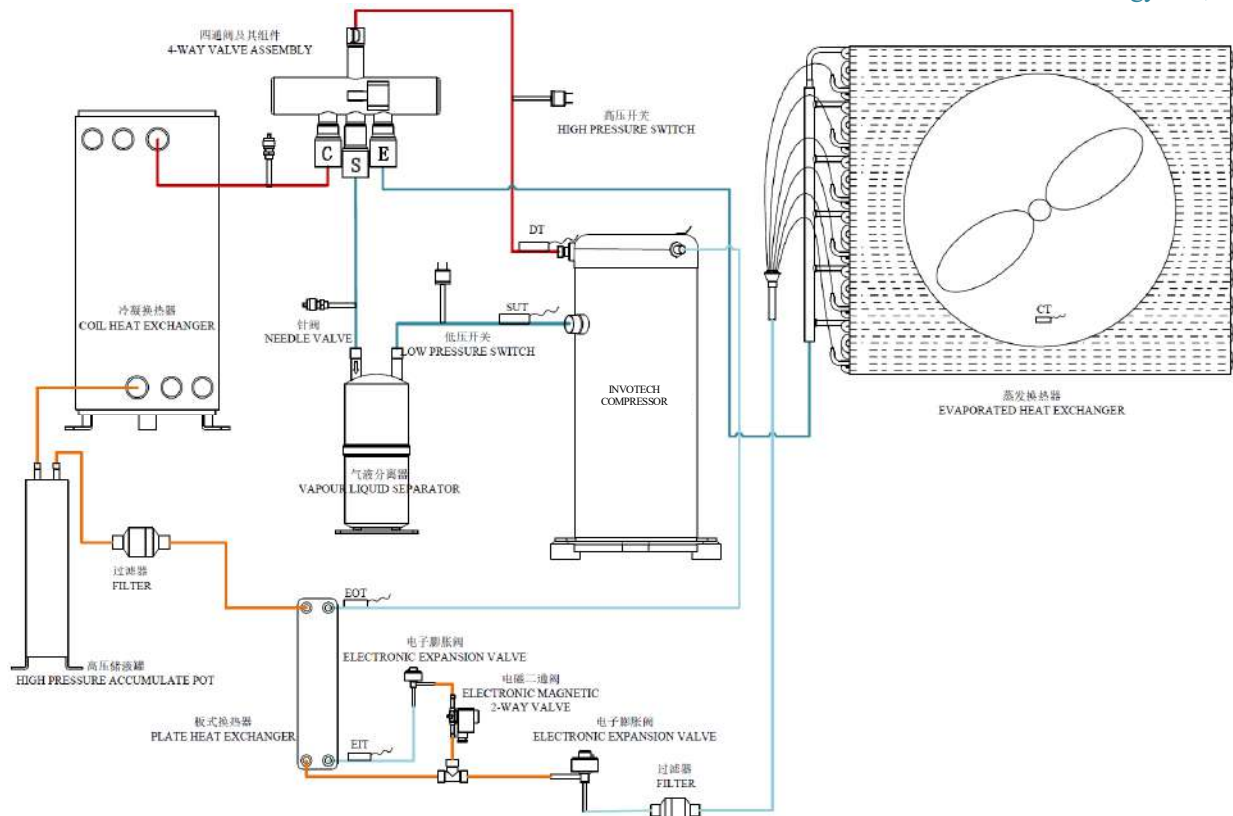


Fig. 7 Typical heat pump system diagram for vapor injection

The heat pump system with vapor injection is equipped with an intermediate heat exchanger on the liquid tube to further cool the refrigerant liquid sent to the evaporator. A part of the refrigerant liquid passes through a small expansion valve and is throttled under an intermediate pressure into the heat exchanger (jet circuit). This part of the refrigerant absorbs the heat from the refrigerant liquid flowing through the heat exchanger on the main circuit. Therefore, the liquid in the main circuit is further cooled to a large subcooling temperature, with a reduced thermal value, so that it flows into the evaporator after the thermal throttle, and can absorb more heat from the air, thereby increase the capacity of the system. The refrigerant in the jet circuit absorbs the heat, becomes the superheated vapor and flows into the jet port of the YW***V (under extreme conditions, it may become saturated steam). This part of the refrigerant is sprayed into the medium pressure cavity of the scroll (separated from the suction cavity of the scroll and does not affect the suction flow of the compressor), to cool the refrigerant gas being compressed, reduce the discharge temperature, be compressed together with the refrigerant in the main circuit and then discharged from the compressor.

It is recommended to install a solenoid valve before the throttle device in the jet circuit. Under the shutdown status or when the vapor injection operation is not required, the solenoid valve is closed to prevent a part of the refrigerant leakage to the scroll when the throttle device cannot be closed completely, or the closing response time of the throttle device is too long.

The jet circuit can be controlled with an electronic expansion valve or thermal expansion valve, instead of a capillary tube. The electronic expansion valve can not only be used to optimize the performance of the system, but also to increase the degree of opening and directly spray the saturated steam to the scroll in some severe conditions to control the discharge temperature quickly and effectively.

Selection of Subcooling Heat Exchanger and Electronic Expansion Valve

It is recommended to use a plate heat exchanger as an economizer. The plate heat exchange must be installed vertically, the jet flows from bottom up, and the liquid in the main circuit flows up down, as shown in Fig. 8. The

recommended distance from the throttle device to the inlet of plate heat exchanger is about 150-200mm.

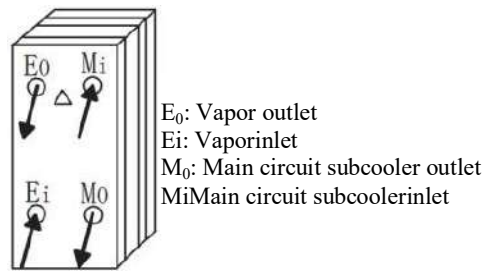


Fig. 8 Typical arrangement of plate heat exchanger as subcooler

The design is optimized under the standard heating conditions at low ambient temperature in the model selection. The optimal temperature at the liquid outlet of the main circuit of the subcooling heat exchanger should be 5°C higher than the saturated evaporation temperature in the jet circuit. The common design parameters are as follows:

TIP = Saturation temperature at the economizer outlet pressure

TM_i = Temperature at the economizer main circuit liquid inlet ~ Temperature at the condenser liquid outlet

TM_o = TIP + TD Liquid temperature at the economizer main circuit outlet

TE_i = TIP + Loss (pressure loss) Temperature at the economizer jet circuit inlet

TE_o = TIP + Superheat Temperature at the economizer jet circuit outlet

H = Thermal

Supercooling = TM_i-TM_o Subcooling temperature after the refrigerant liquid in the main circuit flows through the economizer

Superheat = TE_o-TIP Superheat temperature after the refrigerant in the jet circuit flows through the economizer

TD = TM_o-TIP Temperature difference of economizer heat exchanger

Economizer selection case (under optimized design operating conditions): Compressor model: YW320C1G-V100 / R410A; system design optimization conditions (Ambient temperature: -12°C; Water temperature at the outlet: 41°C).

The key parameter for the selection of the TIP economizer is the saturated evaporation temperature in the jet circuit. The selection can follow the following process: TIP can be estimated with the following parameters:

$$TIP = 0.8T_e + 0.5T_c (\text{°C}).$$

After TIP is estimated, the subcooling temperature at the outlet of the condenser can be estimated at 5K, and the target value of the gas superheating temperature in the economizer jet circuit should be 5K. In this way, on the one hand, the performance of the system can be optimized; on other hand, the reliability of the system can be guaranteed. After these parameters are determined, the heat exchange of the economizer can be determined so as to select a suitable heat exchanger.

Step 1:

Compressor simulation design optimization points: -20/45/5/-15°C (evaporating temperature/condensing temperature/liquid subcooling temperature at condenser outlet/compressor suction temperature).

Step 2:

Based on the calculation of the discharge volume, the theoretical mass flow in the main circuit at the design points is about 337.3kg/hr.

Step 3:

Estimated TIP = 6.5°C

Step 4:

The estimated refrigerant subcooling temperature at the outlet of the condenser is 5K, and the superheating temperature at the outlet in the jet circuit is 5K.

$$TM_i = T_c - 5 = 40\text{°C}$$

$$TM_o = TIP + 5 = 11.5\text{°C}$$

$$HX\ SC = TM_i - TM_o = 40 - 11.5 = 28.5\text{°C}$$

$$HX\ KJ/hr = Me \times (HTM_i - HTM_o) \text{ (heat exchange volume = mass flow} \times \text{thermal difference)}$$

$$= 337.3 \times (269.96 - 217.89) = 17563\text{KJ/Hr} = 4.8\text{Kw}$$

Step 5

Based on the calculated heat exchange volume, the saturation temperature in the auxiliary circuit, the temperature and mass flow at the liquid outlet and inlet of the main circuit of the economizer, the economizer and the throttling element can be selected.

Note: Different economizers and throttle components may be selected under different design conditions and selection schemes. For YW270C1G-V100~ YW400C1G-V100 series compressors, the jet saturation pressure (intermediate pressure) must not exceed 20bar (gauge pressure) when the machine is tested and verified under each operating condition.

The liquid before the throttling element in the jet circuit must be maintained at a certain subcooling temperature, and in the tube design, the liquid must be sucked into the jet circuit sufficiently. If the liquid is not subcooled before the throttling element, or the liquid cannot be sucked sufficiently, the degree of opening of the throttling element in the jet circuit may be too much and the jet pressure may be too high.

The vapor injection is mainly used to improve the energy efficiency of the system and reduce the decay rate of heating under the conditions with low evaporating temperature; under the conditions with high evaporating temperature, the vapor injection may reduce the energy efficiency of the system. When the evaporating temperature is higher than 0°C for refrigeration, it is recommended to close the vapor injection circuit.

When the throttling element in the jet circuit is an electronic expansion valve, under the conditions that the vapor injection needs to be opened, especially at high condensing temperature and low evaporation temperature (high water temperature and low ambient temperature), before the compressor is turned on, the electronic expansion valve in the jet circuit must be opened to an initial degree of opening (it can be a function of the ambient temperature and the water temperature). After the compressor is turned on for a certain period of time, the degree of opening of the electronic expansion valve can be controlled by the discharge temperature, with the reference control logic as below:

- If the discharge temperature is 90-120°C after stable operation, enter the discharge temperature control mode, set the discharge temperature target value to 103°C, and adjust the degree of opening of the electronic expansion valve with the PID algorithm to stabilize the discharge temperature at about 103°C;
- If the discharge temperature is 70-90°C, the control target value is the superheat temperature in the jet circuit. It is recommended to set the superheat temperature in the jet circuit to about 6K, and adjust the degree of opening of the electronic expansion valve with the PID algorithm, to ensure that the superheat temperature in the jet circuit is stabilized near the target value;
- When the discharge temperature is lower than 70°C for 3 consecutive minutes, close the electronic expansion valve to the minimum degree of opening, to increase the discharge temperature to 85°C and then enter the control algorithm of the superheat target value;
- When the degree of opening of the electronic expansion valve is controlled with the superheat temperature as the target value and the discharge temperature reaches or exceeds 97°C, enter the algorithm with the discharge temperature control target value; when the degree of opening of the electronic expansion valve is controlled with the discharge gas as the target value, when the discharge temperature drops to or below 80°C, enter the algorithm with superheat temperature;
- The algorithm should be able to avoid the alternation between the wet injection and the superheated steam jet in a short period of time;
- Must avoid the wet injection as much as possible; at the evaporation temperature of -25°C and below, when the cumulative time of wet injection exceeds 2000h, the reliability of the compressor will be significantly affected.

At any time, when the discharge temperature exceeds 120°C, must shutdown the compressor and check whether its operation exceeds the operating envelope, whether the initial degree of opening of the electronic expansion valve is inappropriate, whether the liquid before the jet circuit valve is not at the subcooling temperature, or whether the liquid is sucked in the injection circuit insufficiently.

During the defrosting process and the compressor is shut down, must close the jet circuit.

Suggestion: When the evaporating temperature is higher than 0°C, please close the jet circuit.

Suggestion: Please install a solenoid valve before the throttle device in the jet circuit, and the solenoid valve should be closed under the shutdown status or when the vapor injection operation is not required.

Installation

Storage, Package and Handling

Storage: The compressor should be packed in a carton and stored in a dry and ventilated environment, the carton should be provided with air holes for external ventilation.

Package: The compressor package must be properly protected to avoid shaking or collision damage during handling process.

Handling: During handling process, the compressor should be kept as vertical as possible, and the inclination angle should not be more than $\pm 15^\circ$. If it is placed upside down and horizontally, it must be placed vertically and held for more than 4h before use.

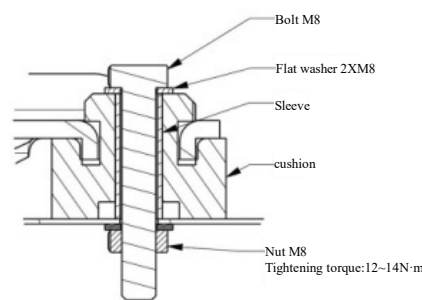
Fixing and Supports

The Invotech scroll compressors are equipped with special compressor support cushions and nuts.

Fix the compressor support cushion on the chassis firstly (determined by the user's production process), lift the compressor to the installation position, and then gently screw the nut with washer, and tighten it to the tightening torque of 13 ± 1 Nm:

When tightening the nut with washer, an excessive force will damage the thread or even cause cracks, resulting in vibration and noise.

In the design, it is required to keep a gap of 0.5~2mm between the nut washer and the upper plane of the compressor support to increase the vibration resistance of the compressor. The compressor support cushion should be added with galvanized steel sleeve to increase the fixing strength of the compressor, as shown in Fig. 9.



Support installation

Fig. 9

Removal of the Sealing Rubber Plugs

The compressor is charged with the dry nitrogen under a certain pressure and then sealed with a sealing rubber plug before leaving the factory.

When it is assembled on-line, the discharge plug should be removed first, and then the suction plug should be removed (after removing the rubber plug, the compressor should not expose to the air for a long period of time, and

the ports should be sealed or welded within 10min).

Use a clean cloth to clean the inner ring of the suction port, to clean the oil film layer for welding operation.

Welding of the Connecting Tubes at the Suction and Discharge Ports of the Compressor

The connecting tubes at suction and discharge ports of the compressor are made of copper-plated steel tubes. In principle, only tubes with clean and dry interior surface and without oxide scale, rust, and phosphate layer can be used.

A certain volume of dry nitrogen with a purity of 99.999% must be charged to protect the welds, otherwise the oxide scales may be produced to block the system.

It is best to use electrodes with at least 15% silver. If the electrodes with less than 5% silver are used, very good welding process must be provided to ensure the connection gap of 0.1mm-0.3mm.

First heat the Zone 1 as shown in Fig. 10 below; when the copper tubes are close to the welding temperature, and then move the welding torch to the Zone 2.

Heat the Zone 2 to the welding temperature and move the welding torch up and down to heat the welding joint evenly in the circumferential direction. Move the welding torch in the circumferential direction and then add the welding material at the same time.

As the welding material flows along the welding joint, move the welding torch to the Zone 3, to heat the Zone 3 in a short time as possible.

The heating time will determine the welding quality. Excessive heating may damage the welding joint. It is recommended to wrap the tubes with a damp cloth before welding operation. The flow time of the welding material should not exceed 15-20s.

The welding material entering into the compressor may cause a fault.

If the vapor injection tube are welded, it must be wrapped with a damp cloth during welding process to prevent damage to the sealing ring in the vapor injection tube from being overheated, as shown in Fig. 10.

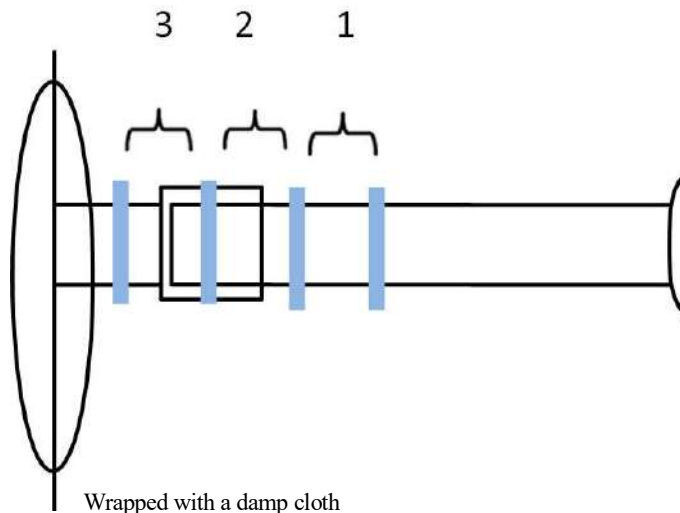


Fig. 10 Welding and heating sequence diagram

Wiring Terminals and Electrical Connections

The compressor wiring terminals are located in the terminal box. Use a cross screwdriver to unscrew the screws around the terminal box to open the terminal box cover. The wiring sequence is shown in Fig. 11. Must pay attention

to the symbol sequence of the corresponding compressor terminals. The grounding hole is in the electrical box and the grounding screw is a self-locking screw with locking device.

For the terminals connected with screws, must follow the torque of the pneumatic tightening tool; otherwise the internal threads of the terminals may be damaged or the screws may be broken. The pre-insulated round terminals should be used to connect the power cables and the compressor terminals.

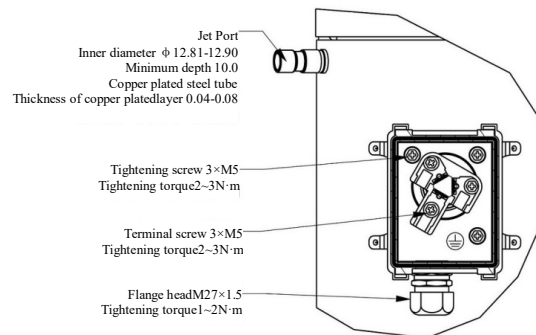


Fig. 11 Compressor motor wiring sequence schematic diagram

Suction and Discharge Ports of the Compressor

Based on different configuration choices of customers, the suction and discharge ports of Invotech compressors can be welded or screwed. In order to ensure the high strength and low leakage rate of the ports, all welded ports on Invotech compressors should be connected with the copper-plated steel tubes.

Rotation Direction of Three-phase Compressor

The scroll compressor is direction-dependent and can only be operated in one direction. For three-phase motors, the operating direction is related to the phase sequence; therefore, there is a 50% chance that the initial wiring may be reversed, resulting in the reverse rotation of the compressor. The equipment manufacturer should provide the appropriate information to contractors for prompts during on-site installation.

After the compressor is powered on, if the rotation direction is correct, the suction pressure will drop significantly and the discharge pressure will rise significantly; on the contrary, if the rotation direction is incorrect, the compressor will make abnormal noise, and the operating current will be significantly lower than the normal value.

A short-term reverse rotation of the compressor has no effect on it; however, a long-term continuous reverse operation may damage it. The internal motor wiring of all Invotech compressors is consistent. Once the correct wiring sequence is determined on a system, it will apply to all Invotech compressors.

Operation under High Vacuum

Do not operate the compressor under a high vacuum; otherwise it may cause a permanent damage to the compressor. A low pressure controller should be equipped to prevent the operation under vacuum. The recommended set value is shown in Table 2.

The scroll compressors (including any refrigeration compressors) are not allowed to vacuum the refrigeration or air conditioning systems.

System Leakage Detection

After the welding operation is completed, the system should be checked for leakage with a refrigerant leakage detector and the mixed gas of the nitrogen and the refrigerant, or with a mass spectrometer and the mixed gas of the

nitrogen and the helium.

Do not use oxygen, dry air, acetylene, or any other gases that promote the oxidation or form the flammable mixtures as leakage detection media. Note: The recommended leakage detection pressure is 3.0Mpa (gauge pressure).

System Pressure Holding

After the leakage detection of the system is completed, there is usually a pressure holding stage; usually, the nitrogen is used to maintain the pressure of no more than 3.8MPa (gauge pressure).

Vacuumping

The proper vacuumping is a very important step to effectively clean the refrigeration system. The air is very harmful to the refrigeration systems and must be removed before the compressor is started. Most of the air in the system can be flushed with dry nitrogen, but when air is trapped in the compressor, especially in the compressor crankcase, it cannot be removed completely with the nitrogen.

The compressor is charged with the dry nitrogen when leaving the factory, and it should be discharged before connecting to the system.

Invotech strongly recommends to remove impurities such as air and moisture from the system with the vacuumping method in three times (the system should be vacuumped to the absolute pressure of 1500 umHg in the first two times and to 500 umHg in the third time according to the equipment manufacturer's requirements, the degree of vacuum must be checked with a vacuum gauge). Charge 2 bar (relative pressure) of dry nitrogen between two vacuumping operations. The vacuumping connection tubes must be connected to the high pressure side and the low pressure side of the system at the same time. The inner diameter of the connecting tubes, including the diameter of the joint, should not be less than 5mm, because the too small diameter may decrease the vacuumping speed, and generate a pressure drop, resulting in inaccurate vacuumping readings.

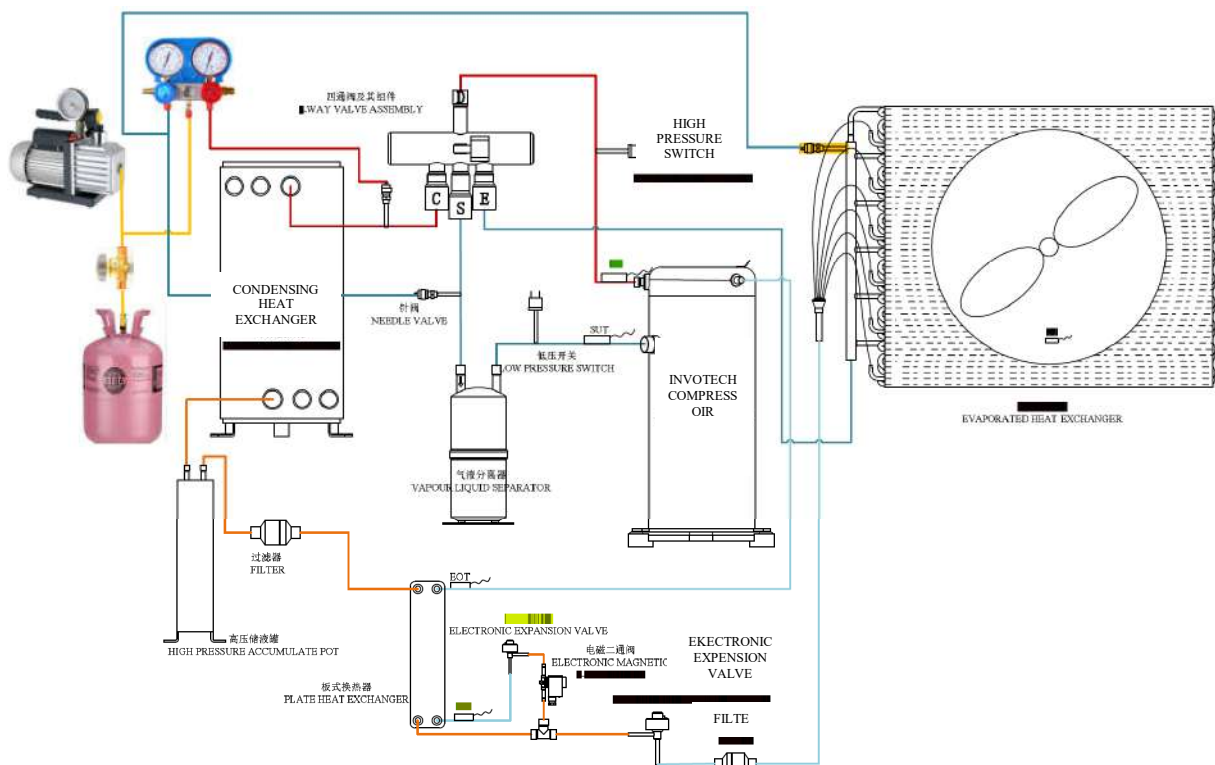


Fig. 12 System vacuumping and refrigerant charging connection schematic diagram

Refrigerant Charging

The compressor cannot be started until the refrigerant is charged.

When charging the refrigerant, a scale must be used to control the charging mass. It is recommended to install a filter drier between the refrigerant cylinder and the multimeter to prevent moisture from entering the system during charging process. The refrigerant cylinder should be connected to both the high and low pressure sides of the system. If possible, the solenoid valve in the liquid tube should be powered (if the system is equipped with a solenoid valve in the liquid tube; however, in this case, the compressor cannot be powered). Ensure that the liquid refrigerant is charged into the system (at high pressure and low pressure sides), do not connect the low pressure charging port directly to the compressor suction port, and connect it to the evaporator header tube. Based on the designed charging mass, charge the refrigerant as much as possible (at least up to 70% of the rated charging mass) before starting the compressor. When the system pressure is equal to the cylinder pressure, disconnect the high-pressure side from the cylinder, start the compressor, and continuously charge the liquid refrigerant into the system until the rated charging mass is reached. It is best to charge the refrigerant from the high pressure side and the low pressure side at the same time, or only from the high pressure side; if only the refrigerant is charged from the low pressure side, it may cause the scroll to be axially sealed and temporarily fail to be started.

Do not close the suction shut-off valve while the compressor is operated (if any).

Electrical Safety and High Voltage Withstand Test

The electric control device and the compressor must be grounded separately to ensure the safety of the system and operation.

During the high voltage withstand test, the liquid level may affect the insulation performance: When a large amount of refrigerant flows into the compressor, the motor may be immersed in the mixture of the refrigerant and the oil, resulting in an increase in leakage current; if the leakage current is increased, the compressors can be operated for several minutes, to drain a large amount of refrigerant from the compressor and lower the liquid level before the test; or the crankcase heating belt can be heated for more than 2h and the compressor can be jogged for three times before the test.

The specifications of the Hi-Pot Test for Invotech compressors are 2000V/1sec (leakage current < 5mA).

Note: It is not allowed to start the compressor and carry out high voltage test and dielectric strength test under a vacuum status, so as not to damage the motor.

Online Running Test

The standard machine should match the machine under test: if the flow restriction is too large, it will cause the vacuum operation and overheating; if the flow restriction is too small, it will cause a lot of liquid flood back, resulting in big noise. For off-line compressors, please contact Invotech engineers in time for processing and judgment. For compressors that cannot be immediately sent back to the factory for analysis, the suction and discharge ports should be plugged with sealing plugs, and the compressor should be packaged and sent to Invotech factory for processing. For the compressors to be sent to the factory for analysis, the detailed information such as its model, machine number and fault cause should be completed.

The Invotech flexible scroll compressors have a running-in effect, and before the performance test bench, they should be operated for running-in with a large load for 48h.

Aftersales and Repairs

Compressor Performance Check

The Invotech scroll compressors are not equipped with the built-in suction valve plates, and there is no need to test the degree of low pressure pumped to verify the performance. Such tests may damage the scroll compressors. It is recommended to verify their proper performance with the following test procedures.

1. Verify the correct power voltage.
2. Check whether the external protector of the motor is activated, or whether the motor is grounded. If the external protector of the motor is activated, it must be cooled down for a period of time, and can be reset after power off.
3. Connect the high pressure gauge and low pressure gauge to the system, and start the compressor. If the suction pressure is obviously too low, there may be a lack of refrigerant in the system (refrigerant leakage), or the tube is blocked.

If the suction pressure does not drop and the discharge pressure does not rise to the normal value after starting the compressor, cut off the power supply, change any two lines of the three-phase lines and restart the compressor. If it is operated normally, it means that there is reverse rotation; if there is still no suction and discharge operations, the compressor may be damaged.

Check the operating voltage, operating current, suction pressure, discharge pressure and intermediate pressure of the compressor during operation, and compare them with the operating current (same electrical system), same suction pressure (saturated evaporating temperatures), same discharge pressure (saturated condensing temperature) intermediate pressure and power supply voltage published under the same operating conditions for any obvious abnormality; if the difference between the actual operating current and the published current under the operating conditions is more than 15%, the compressor may be damaged.

Repairs

When removing the system components, the refrigerant should be collected first from the high-pressure side and the low-pressure side at the same time. If done only from the high pressure side; if it is only collected from the high pressure side, the scroll may be sealed, resulting the refrigerant to be trapped at the low pressure side. When removing the connecting tubes, the mixture of the refrigerant and the oil will spray out and may cause a fire in the event of an open flame; therefore, in this case, the pressure at the high-pressure side and the low-pressure side must be checked with a pressure gauge. This consideration must be indicated on the relevant product samples and manuals, the assembly line, and the work instructions.

After the compressor is damaged, it is generally necessary to replace the gas separators, oil flood back capillary tubes, and the dry filters on the suction and dischargetubes of the compressor, so as to reduce the interference of the water content in the system, and avoid the compressor damage again from the oil contamination in the system.

For a newly replaced compressor system, it is recommended to charge the refrigerant from the high pressure side. When the suction pressure on the low pressure side of the system is not up to 0.5MPa, do not power on the compressor to avoid the vacuum arcing on the suction side of the compressor; when the suction is blocked, do not operate the compressor.

On-site Removal of Compressor

Must recover the refrigerant from both high and low pressure sides of the system at the same time, and then cut the copper tubes as close as possible to the compressor with a cutter, instead of the welding cutting method.

Reconnection

The silver electrodes with at least 5% silver, or a fluxed silver electrodes should be used, as shown in Fig. 10.

Reconnect the copper tubes to the suction and discharge ports.

Heat the Zone 1 evenly, move the welding torch slowly towards the Zone 2. When the welding port reaches the welding temperature, add the welding material.

Move the welding torch evenly along the circumference of the joint so that the welding material can be filled into the joint evenly and thoroughly.

Move the welding torch slowly towards the Zone 3 so that so that the welding material can be filled into the joint evenly and thoroughly.

Do not overheat the joints.

Suggestions on System Test and Verification

Test item	Test conditions	Verification purpose	Remarks
Rated heating capacity	100% rated heating capacity	Heating capacity \geq Nameplate value \times 95% Heating power \leq Nameplate value \times 110%	
Rated heating capacity	Heating to specified temperature	System running detection time and start-stop logic verification	
Standby power test	Power under power-on status	The standby power can meet the design requirements	
Stop power test	Power under stop status with power supply	The stop power can meet the design requirements	
Maximum load heating capacity	High temperature conditions and low voltage	The system can be operated normally or automatically resumed from the protection	The system is reliable
Maximum load heating capacity	High temperature conditions and low voltage	The system can be operated normally or automatically resumed from the protection	The system is reliable
Defrosting capacity	Defrost conditions (2/1°C)	After 3 cycles or 3h of operation, the frost can be removed completely, and the program can meet the requirements	
Defrosting capacity	Severe defrost conditions (0/0°C)	After 3 cycles or 3h of operation, the frost can be removed completely, and the program can meet the requirements	Optional
Low temperature heating capacity	Low temperature conditions	The system can be operated normally or automatically resumed from the protection	There is no liquid flood back in suction and the oil level in the compressor can meet the requirements
Heating capacity under variable operating conditions	Interval tests under operating conditions	Test the heating capacity and power based on the temperature changes, and draw the performance curve	
Oil flood back test	Rated heating process and the oil flood back program runs	Check the oil flood back program, and the return oil level can meet the design requirements	
Refrigerant migration and deposition test	At the low temperature of -20°C, the system is powered on and standby for 24h, and then carry out the heating operation	The system is operated normally, there is no liquid shock in the compressor, and the oil level is normal	

Condenser blocking test	100% operation, no heat exchange in the condenser	The system can be automatically resumed from the protection	Optional
Evaporator blocking test	100% operation, no heat exchange in the evaporator	The system can be automatically resumed from the protection	Optional
Compressor start-stop test	In heating mode, the compressor electrical control device starts and stops periodically	The compressor starts and stops are normal, the current peak value is normal, the compressor temperature is normal, and the compressor oil level is normal.	Optional
Allowable low voltage start test	In heating mode, the input voltage is the lowest allowable start voltage	The compressor starts and stops are normal, without damage to the components	Optional
Moisture test	Heating test in the ambient with a moisture content of more than 85%	No damage to system components or unprotected stops	Optional
Noise test	Noise test in the speed range under rated heating conditions	The maximum Noise value can meet the design requirements	
Tube stress test	Stress test of benttube and stressed parts under rated heating conditions	The maximum stress can meet the design requirements during starting and stopping processes	
Tube strain test	Amplitude test of the tube connected to the compressor	The maximum amplitude of the tube can meet the design requirements at different speeds of the compressor	
Transportation test	The whole machine is transported by the weight transport table within the specified time limit or for a long-distance.	The whole machine is not damaged and the package is reliable.	Optional
Drop test	Select the drop height, drop surface and number of drops according to the requirements	The whole machine is not damaged and the package is reliable.	Optional
Rain test	The outdoor machine is tested in the rain test room according to the requirements	There is no water on the electrical control device and the machine can be operated normally	Optional
Starttest at low ambient temperature	High water temperature condition	The response speed can meet the requirements when the discharge temperature is within the control range	
Starttest at low ambient temperature	Low water temperature condition	The machine can be operated normally	