Scroll compressors

Fitters Notes (Part 9)

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The “Fitters Notes” series provides useful practical information for the everyday work of fitters. The previous article dealt with electronic expansion valves. In this article (Part 9), we examine another main component of refrigeration systems: the compressor, and in particular scroll compressors.

The compressor is a key element of every compression refrigeration system. It raises the pressure of a refrigerant in the vapour state from a low level (low-pressure or suction side) to a high level (high-pressure or discharge side).

There are various types of compressors available, with different operating principles.

They include:
- Scroll compressors
- Screw compressors
- Rolling piston compressors
- Turbo compressors
- Reciprocating compressors

This article concentrates on scroll compressors. Scroll compressors are used very extensively in refrigeration systems, traditionally in chillers. They are also gaining more market share in other areas, especially heat pumps.

However, scroll compressors are generally available for use in ordinary refrigeration systems as well, and even in freezer systems.

Danfoss scroll compressors use two different compression methods. In the units that are painted blue, radial sealing (between the faces of the scroll spirals) is provided exclusively by an oil film, while flexible mechanical seals are used for axial sealing. In these units, the two spirals are not pressed together, but instead remain fully inflexible, even in compression operation.

The situation is different with the black-painted Danfoss scroll compressors, which operate on the “compliance principle”.

This means that one of the two spirals is pressed against the other spiral by moderate pressure from the “pockets” in the scroll set where the full compression level has not been reached.

As a result, the two spirals are “run in” together, in a manner of speaking. The run-in phase lasts up to 72 hours after the compressor is first put into service.
If you look up “compliance” in a dictionary, you will see that the technical meaning is “ability to deform under stress”, while the more general meaning is “following rules or standards”.

The appropriate meaning depends on the actual situation. In the case of a compliant scroll compressor, it means a flexible interplay of forces between the two scroll spirals combined with self-optimisation of their interaction.

In this connection, as a fitter you should bear in mind that with these black compliance compressors (the compressor type designation always begins with “H”, such as “HRP”), the capacity of the compressor may be somewhat less when it is first put into service.

This is usually not especially noticeable in normal use, but it is very important if you are making capacity measurements on a test stand. The blue scroll compressors deliver their full rated capacity right from the start.

**Installation and service**

The compressors are delivered pre-filled with the right amount of oil. After installation, you should check the oil level at the sight glass near the bottom of the compressor (standard fitting with the blue scroll compressors) after the compressor has been operating for while. The ideal oil level is at the centre of the sight glass, but anywhere from ¼ to ¾ is acceptable.

All Danfoss scroll compressors are fully suction-gas cooled. This means that a sound insulation hood can be fitted if necessary, since the compressor dissipates all of its excess heat via the refrigerant flowing through the compressor. The refrigeration circuit ports are arranged vertically with this type of compressor, with the suction side at the bottom (large connection) and the discharge side at the top (small connection).

Both ports are formed as Rotolock threaded connections or solder stubs integrated directly into the compressor. Rotolock valves should be used for initial installation, at least with units fitted with Rotolock threaded connections, since this makes servicing the compressor or the refrigeration system considerably easier and makes it easy to fit a high-pressure or low-pressure switch. Here you should bear in mind that with a Rotolock valve the port closest to the spindle can be shut off, so it can be used for connecting a service pressure gauge.

The other port can be used for a pressure switch (this port cannot be shut off). Three other small ports are usually located on the compressor housing of an SZ or SM scroll compressor. The first is a low-pressure port, which is normally not used, and the second is an oil overflow port, which is only needed when compressors are operated in tandem. With tandem operation, a 10-mm copper pipe is connected to the other compressors in the tandem set to provide oil equalisation, and the suction lines to the tandem compressors are routed as symmetrically as possible.

Supplementary check valves in the individual pressure lines are not necessary because a check valve is already present inside the scroll compressor. The third small port is something special. If the NPT plug in the oil drain port is replaced by a suitable nipple with a 7/16 UNF pressure gauge fitting, you can change the compressor oil without tipping it. All you have to do in this case is to apply a slight positive pressure to the suction side of the compressor and let the oil flow out of the compressor via this port and the service pressure gauge. This is possible thanks to a small copper pipe inside the compressor that runs from this port to the bottom of the compressor sump.

The compressor is installed on rubber mounts. If you are not already familiar with scroll compressors, you should bear in mind that with this sort of compressor the high-pressure portion, which means the upper 20% of the compressor, is at the discharge temperature (hot-gas temperature).

This differs from the situation with fully hermetic reciprocating compressors, which have all parts of the compressor housing (except the discharge stub)
at the suction side and are not hot to the touch. The discharge temperature is always a critical aspect with scroll compressors. For example, the discharge temperature of a scroll compressor used in an air conditioning or heat pump system is not especially high if it is operated with a customary evaporation temperature of 0 °C or 10 °C.

This means that the temperature is rarely higher than 100 °C, which does not present a problem for the compressor, bearings, scroll set, or refrigerating-machine oil. However, if this sort of compressor is operated for a relatively long time with a suction pressure well below its operating limit, for example due to persistent strong throttling of the evaporation pressure regulator or for some other reason, the discharge temperature can quickly rise to an excessively high level.

For this reason, it is strongly recommended to install some form of compressed-gas discharge temperature monitoring in a system with a scroll compressor or retrofit it in existing systems if it is not already present. This task can be handled by a simple mechanical thermostat with a remote sensor, such as the Danfoss KP 81. It is not necessary to adjust the thermostat setting extremely close to the operating point; a good rule of thumb here is 120 °C, with a maximum of 135 °C.

**Electrical connection**

You should fit a crankcase strip heater to the compressor for outdoor installation or in situations where the compressor can be exposed to low ambient temperatures. It should always be switched opposite to the compressor (strip heater off when the compressor is running, strip heater on when the compressor is not running).

Most blue scroll compressors in our market are built as three-phase, 400-volt units. The electrical connection is relatively simple, since the compressor has an internal wye connection and there is no need to fit jumpers in the junction box. There are three leads, which are connected directly to the three phase conductors from the power contactor (or from the motor protector in the electrical cabinet in the ideal case). It is essential to ensure that the scroll compressor rotates in the right direction when it is running. If you hear loud mechanical noises and the service pressure gauge does not show the usual pressure difference between the high-pressure and low-pressure sides, the compressor is most likely running in the wrong direction. To correct this, swap two of the phase connections on the compressor terminal strip.

You can use a voltage checker to check that the electrical power supply at the junction box is OK. The voltage between any two phases should always be around 400 V. To provide additional protection against overheating and excessive power consumption, some blue compressor models (SZ/SM84-110 and SZ/SM84-120) have a bimetallic cut-out switch at the wye point of the motor windings. This means that if you measure a nearly infinite resistance between the three motor leads of the compressor (disconnect the supply voltage first!); you can assume that the internal motor protection switch has tripped. The bimetallic switch returns to the closed state after the motor cools down. When the motor is ready for use, the resistances measured between each pair of leads are nearly identical. Depending on the capacity of the compressor, they should lie in the range of 0.4 ohms to less than 10 ohms.

However, you still have to be careful even if the compressor has internal motor protection. Other compressor models, such as the SZ/SM115 and SZ/SM125 to SZ/SM185, do not have a built-in motor protector at the wye point of the motor windings. These models only have an extra bimetallic switch with external leads, which opens when the internal temperature of the compressor is too high. This bimetallic switch is potential-free (floating), and it should be wired into the protection circuit ahead of the compressor contactor (ahead of “A1”). There is yet another type of motor protection available with the blue “Performer” compressors: the SZ240, SZ2300 and SZ380 models have a Kriwan INT69 thermistor motor protection unit.

The M1/M2 contact of the INT69 is potential-free (floating) and should be wired into the protection circuit ahead of the compressor contactor (ahead of “A1”). This is similar to the connection arrangement with a bimetallic cut-out switch. These INT69 requires a supply voltage of 230 V or 24 V, depending on the model. This information is important for the fitter, since it means that in addition to installing the usual power cable to the compressor (with the three phase conductors and protective earth conductor); the fitter must also install the neutral wire for the motor protection module supply voltage and a pair of conductors for the safety circuit of the compressor contactor. When the scroll compressor is operating, the motor protection unit constantly monitors the thermistors fitted in the compressor to check whether the temperatures in the compressor are OK. If an overheating condition occurs, the contact between M1 and M2 opens and de-energises the motor contactor.

The rotation speed of these compressors is approximately 2900 rpm with a 50-Hz supply, since the motor is wound with a single pole pair. With a 60-Hz supply, the motor runs correspondingly faster (approximately 3480 rpm) than with 50 Hz, since the rotor turns at a speed proportional to the AC line frequency (Hz = cycles per second, so the direction of current flow changes 50 times per second at 50 Hz).
Coming up in the next issue
In the next instalment of Fitters Notes at this location, we turn our attention to solenoid valves. You can read more about them in the next issue.

Information
The “Fitters Notes” series is based on the handbook of the same name produced by Danfoss, which discusses the basic principles of commercial refrigeration systems and the associated basic components.

You can view the Fitters Notes handbook from here:
http://www.danfoss.com/BusinessAreas/RefrigerationAndAirConditioning/EducationAndTraining/Fitters+Notes.htm

This “Fitters Notes” series is aimed at refrigeration fitters in servicing, system construction, people entering refrigeration engineering from other disciplines, trainee refrigeration fitters and anyone who would like to gain a basic practical knowledge of refrigeration in a series of articles.

The discussion avoids formulae as far as possible and only a small amount of prior technical knowledge is necessary. Fitters like using rules of thumb and so we will provide plenty of them, even if this sometimes makes it necessary to accept generalisations that are not always entirely accurate from an academic viewpoint. Unless otherwise stated, this series always refers to refrigeration systems using fluorinated hydrocarbons, such as R134a, R404A/R507 and R407C (i.e. not ammonia refrigeration systems).