Scroll compressors for refrigeration

The compressor is the heart of every compression refrigeration circuit. It takes refrigerant in vapour form from a low pressure level (low-pressure suction side) to a high level (high-pressure discharge side).

There are several compressor types. For example, there are scroll compressors, screw compressors, rotary vane compressors, turbo compressors and reciprocating compressors. Today, we are focusing on scroll compressors for refrigeration applications.

Scroll compressors are in widespread use in air-conditioning systems (their classic application is chiller). Scroll compressors are also gaining an increasing share of the market in the heat pump sector too. However, scroll compressors are highly suitable for refrigeration applications as well.

Construction and function

In Danfoss scroll compressors, the crankshaft is arranged vertically. The scroll set is located above it. This scroll set comprises one fixed and one orbiting spiral. These two spirals mesh with one another, compressing the refrigerant through an orbital motion from the outer part of the scroll set towards the middle. As a result of this principle, there are various stages of compression (differently sized “pockets” in which compression is currently occurring) at any point in the compression process.

Compared to reciprocating compressors, scroll compressors expel smaller portions of refrigerant more frequently. This leads to smaller pulsations. For installers, this means that mufflers to dampen
pulsations do not need to be used as often. Systems featuring scroll compressors are also much less likely to suffer problems with noise or malfunctions in pressure switches caused by pulsations. When a compressor is operating, one of the two spirals is pressed against the other with the help of a medium pressure from a “pocket” in the scroll set where full compression has not yet been achieved. This results in the two spirals “engaging” with one another. However, it takes a maximum of 72 hours of operation before this “engagement phase” is complete.

In practical operation, the two scroll spirals interact flexibly with one another, automatically optimising this interaction in the process. Installers should therefore note that MLZ compressors may offer slightly reduced performance when put into operation for the first time. During normal operations, this reduction in performance is not usually noticeable but is highly significant when carrying out performance measurements on test beds.
**Installation and service**

All Danfoss scroll compressors are 100% suction-gas cooled. This means that an acoustic jacket can be fitted as the compressor expels the entire excess heat via the refrigerant passing through it. With these compressors, the connections for the refrigeration circuit are arranged one above the other, with the suction side at the bottom (large connection) and the discharge side at the top (small connection).

Both connections are brazed and are integrated directly into the compressor. Inside the “scroll compressor head”, there is a non-return valve which prevents the scroll set from rotating backwards when the compressor is switched off.

Scroll compressors are installed on cushioned rubber mounts. When you first come into contact with scroll compressors, you should bear in mind that the head, i.e. the top 20% of the compressor, on this type of compressor is at compression discharge temperature (hot gas temperature). This is not the case with hermetrical reciprocating compressors.

In this case, all parts of the housing (with the exception of the pressure joint) are on the suction side and are therefore not at a high temperature. The compression discharge temperature in particular is always an issue with scroll compressors. For example, “MLZ” scroll compressors will exhibit no abnormalities as regards compression discharge temperature if they are operated at the usual evaporation temperatures of -10°C. This means that the figure will exceed 100°C only in the most exceptional cases – not a problem for the compressor, bearings, scroll set and refrigeration oil.
If, however, a compressor of this type is run for long periods with the suction pressure well below its operating limits (e.g. as a result of the permanent, heavily throttling of an evaporation pressure controller etc.), this can quickly lead to excessive pressure joint temperatures. It is therefore advisable to fit a discharge gas temperature monitoring system to units featuring scroll compressors or to retrofit such a system if it is not already fitted. A simple mechanical thermostat with a remote sensor (e.g. “KP 81”) could perform this task. It is not necessary to set the temperature extremely close to the operating point (135°C maximum, 120°C is a good rule of thumb here).

**Multi-refrigerant capability**

“MLZ” refrigeration scroll compressors are approved for use with the standard refrigerants R404A, R507 and R134a. If R404A and R507 are used, the operating limits allow evaporation temperatures of between -30°C (with restricted condensing temperature) and +10° with a condensing temperature of up to 60°.

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**MLZ operating envelope R404A/R507**

A reduction in condensing pressure (as is often the case in modern refrigeration systems) is possible with evaporation at temperatures from -30 to -10°C and even as high as +10°C. Many reciprocating compressors are unable to achieve this figure.

“MLZ” compressors with R134a can be operated at evaporation temperatures of between -15 and +15°C. Given that condensing temperatures of up to 74°C are possible, the “MLZ” is equally suitable for seasonal heat pump operation as it is for heat recovery.

R404A offers a higher volumetric cooling capacity than R134a. As a result, a compressor with R404A offers a higher cooling capacity with the same evaporation temperature than the identical model with R134a.
These differences in cooling performance resulting from the particular refrigerant used can have commercial benefits too. An important advantage lies in the fact that they allow greater flexibility on the part of the customer.
If, for example a new system is being built and the customer is still not sure whether there are plans to expand it in the next few years, it is advisable to install a multi-refrigerant-capable “MLZ” scroll compressor operating with R134a. If, after five years, a service station shop for example is to be extended, it will then be possible to gain additional capacity without having to replace the scroll compressor simply by changing the refrigerant to R404A. The customer benefits as the R134a refrigerant is very good in energy terms and is inferior to R404A (R507) only in terms of its versatility.
For commercial refrigeration applications, e.g. service station shops etc., the “MLZ” compressors are available already integrated into fully equipped “Optyma Plus” condensing units with fan speed control, a weatherproof housing, a compressor contactor, an isolator switch, a dryer and a sight glass. The time saved when installing equipment on site is one of the main reasons for using such ready-to-install condensing units.

**Lubrication**

The quantity of oil required is supplied along with the compressors. Once a compressor is installed and has been running for a certain period of time, it is advisable to check the oil level via the oil sight glass in the bottom part of the unit. Ideally, the oil level should come half way up the oil sight glass. However, 1/4 or 3/4 is also acceptable.
At the bottom of the housing, there is an oil drain connection which allows you to drain off oil without having to tip up the compressor. To do so, all you need to do is create a slight overpressure.
on the suction side of the compressor and then drain off the oil from the compressor via this connection and the service manometer.

“MLZ” compressors come ready-filled with a PVE (polyvinyl ether) “oil”. Unlike conventional POE (polyolester) lubricants, PVE offers the advantage of not reacting chemically with water and forming acid. Although similar in hygroscopic terms to POE oil, its special property makes it easier to remove or evacuate any moisture in the system. Its compatibility with R22 is another interesting feature. This allows flexibility when responding to export enquiries from regions such as Latin America where R22 is still the dominant refrigerant. To ensure optimum lubrication of the compressor inner parts as well as good oil return, the scroll compressor should be started no more than twelve times per hour and remain switched off for at least a minute after each stoppage.

![Scroll compressor in “Optyma plus” condensing unit](image)

**Electrical connection**

If the compressor is installed outdoors or may be subject to low ambient temperatures, a crankcase heater should be used. This should always operate anti-cyclically to the compressor (i.e. compressor running – crankcase heating off, compressor stopped – crankcase heating on). The “MLZ” scroll compressors are usually marketed in a three-phase 400 V design. The electrical connection is relatively simple as the compressors come internally connected via a star point and no bridges in the terminal box are needed. There are three connecting pins to which the three phases coming from the power contactor (or ideally from the motor contactor in the switching cabinet) can be directly connected.

It is essential to ensure that the scroll compressor rotates in the correct direction. If loud mechanical noises occur and the usual pressure difference between the high and low pressure is not indicated by the service manometer, it is highly probable that the scroll compressor is rotating in the wrong direction. To solve this problem, you should swap two of the phases on the compressor terminal board. You can check whether the power supply is in order by using a voltage tester on the compressor terminal box.

The outer conductors (measured phase against phase) should always show a voltage of around 400 V. For additional protection against excessive temperatures and currents, a bimetallic circuit breaker is built into the star point of the windings. Generally speaking, this means that the internal motor protection system is triggered if an “infinitely high resistance” between all three pins is encountered when measuring the resistance in the compressor (having disconnected the power supply beforehand). As soon as the compressor has cooled down, the bimetallic circuit breaker switches the
power supply back on. If the electric motor is operational, the three resistances measured at the pins are close to each other. The resistance in ohms is in the single figures, depending on the compressor's power rating. At 50 Hz, the rotational speed of these compressors is around 2,900 rpm as the electric motor is wound with a pair of poles. At 60 Hz, for example, the compressor would run correspondingly faster (approx. 3,480 rpm) than at 50 Hz as the compressor’s rotor is governed by the relevant mains frequency (Hz = 1/s means that with 50 Hz alternating current the direction of current changes 50 times per second).