Hermetic reciprocating compressors

The compressor is the core of every compression refrigeration circuit

It brings vaporous refrigerant from a low pressure level (low / suction pressure) to a high level (high / discharge pressure).

There are compressors in different functional principles. There are for example scroll compressors, screw compressors, rotary compressors, turbo-compressors and reciprocating compressors.

Today we are going to concentrate on reciprocating compressors and in particular on those types with hermetic design.

Hermetic reciprocating compressors are different from structurally related types like the semi-hermetic (motor and compression mechanics form a unit) and open reciprocating compressors (motor separate from the compression mechanics) in that they have a sealed design.

In a hermetic reciprocating compressor, as a result of the perfect hermetic sealing of the refrigeration circuit on the compressor body, unlike the two alternative variants – there are no refrigerant leaks possible.

Hermetic reciprocating compressors are the most commonly used compressors in the refrigeration market. This is primarily due to the fact that nearly all compressors in white goods are hermetic reciprocating compressors.

But there is also a preference for these types of compressors in commercial refrigerating systems. They are suitable for air conditioning, cold rooms or low temperature applications, the technology is very reliable, and they come in many different designs for all common refrigerants. As our example we shall be dealing with the household (black) and commercial (blue) reciprocating compressors from Danfoss.

Compressor cooling and assembly

The household (small black) compressors of the series PL, TL, FR, NL and SC are all one cylinder machines with vertically arranged crankshaft. They are usually supplied sufficiently full of oil, so that as a rule you do not have to add any oil (at least for more or less compact systems).

In the small sizes, static cooling through the ambient air is usually enough but in the larger black compressors, either oil cooling or fan-cooling is necessary.

Household (black) reciprocating compressors – displacement 2 to 21 cm.

This is the reason why these compressors should not be fitted with an acoustic hood.

A look at the relevant data sheet will provide information as to whether static cooling (“S”) is sufficient, or if in fact fan (“F”) ventilation or oil (“O”) cooling must be used.
In the oil cooling, along with the three standard connections for the suction-, the process- (also on suction pressure level – for filling the refrigeration circuit – used mostly in mass production) and the discharge connection, there are two additional pipe connections at the lower area of the compressor.

These enable the refrigerant from a split condenser to be used for cooling the compressor. Theoretically water could also be passed through the oil cooler for cooling using a small pump, as there is no direct contact between the inside of the compressor and the oil cooling loop.

If the compressor has an oil cooler but it is not used, then it can simply be ignored (soldering to seal is not necessary). The solder connections of these compressors are covered with capsolutes, to prevent unnecessary foreign particles or moisture entering the compressor.

To remove these capsolutes, there are special capsolute lifters, with which all seals should be opened. This means that even if the process connection is not required, it must absolutely be cleared of capsolutes and soldered closed.

The compressors have to be mounted on rubber grommets. These rubber grommets should always be used, as the buffering along with the internal suspension springs of the inner compressor block absorb the forces as the compressor starts and stops.

**Electrical connection**

For outside assembly or if low ambient temperatures on the compressor cannot be ruled out, belt crankcase heater should be used.

This should always be switched counter-cyclically to the compressor (compressor running – crankcase heating off, compressor idle – crankcase heating on). The electrical connection of these household (black) compressors may not be complicated, but there is some devil in the detail.

As these compressors are operated with 230 V single-phase, the problem of starting the compressor must initially be solved.

For this purpose the 230 V alternating current motor has a main winding and also a start winding. The start winding switched on for a short time at the start phase and switched off after the start.

After this the 230 V compressor runs exclusively with the main winding. Switching off the start winding can be done in different ways. With the so-called HST starting device (“High Starting Torque”) the supply for the start winding is electromechanically switched off by a relay. The HST configuration can be used for expansion valve operation and for capillary tube operation, in other words for systems with and without pressure equalisation when the refrigerating system is idle.
The LST starting device ("Low Starting Torque") should only be used for capillary tube plants (e.g. cabinets or show cases with capillary tubes as expansion device), as this cannot start the compressor at differential pressure.

Technically the LST configuration is a PTC resistor (Positive Temperature Coefficient). If a PTC resistor becomes warm then it becomes high resistance and thus virtually switches off the path to the start winding.

While HST starting devices are always fitted with a starting capacitor or starting capacitor and run capacitor, the LST variant can work without a capacitor or at most with a run capacitor. For the electrical check as to whether the electric motor values of this type of compressor are correct, measuring the Ohm values can give the critical information.

The compressors have three connecting terminals in the terminal box. At the top left is the connection of the main winding; at the top right that of the start winding and at the bottom the shared measuring and connection point.

If you measure from the top left to the bottom, you can measure the Ohm value of the main winding, from the right downwards the value of the start winding and from top to top the sum of the two resistance values of both windings.

**Right:** *HST (high starting torque) device*

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**Compressor protection**

Household (black) Danfoss reciprocating compressors have as a rule an internal motor protection (bi-metal) in the load circuit to protect them from excessive currents and temperatures. This is located between the internal electrical joint of the main and start winding and the connection "G" (bottom pin on the compressor) and is placed inside the compressor.

It is thus very likely that the internal bi-metal motor protection has switched off if a low double-digit Ohm value is detected in the measurement between “top and top” and if an infinite big resistance is detected in the measurements from “top to bottom” on both sides.

This protection device automatically switches back, if the temperature has fallen back again to a reasonable value. The speed of these compressors at 50 Hz is around 2900 U/min, as the electric motor is wound with one pair of poles.

At 60 Hz for example the compressor would run correspondingly faster (approx. 3480 U/min) than at 50 Hz, as the rotor of the compressor follows the relevant mains frequency (Hz = 1/s means, that at 50 Hz alternating current 50 times a second the current direction is changed).

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**Fitting and Service**

In the commercial (blue) reciprocating compressors of the series MTZ, MT and NTZ by Danfoss, the crankshaft is also fitted upright, but they come in single, two and four cylinder versions.
Commercial (blue) reciprocating compressors – displacement 30 to 271 cm³

These compressors contain the requisite amount of oil on delivery. Checking the oil level after a certain running time after installation is advisable and can be done easily via the sight glass in the lower part of the compressor. Half the height of the sight glass is ideal and 1/4 to 3/4 can be tolerated. All compressors in these series are 100% suction gas cooled. This means that, if be fitted, as the compressor gives off all the excess heat via the refrigerant passing through it.

The refrigerating connections in the blue compressors for commercial cooling applications are located one above the other – suction connection on top (large connection) and discharge connection bottom (small connection).

Both are designed as Rotolock screw connections, so that if the compressor is replaced no soldering work is required. On initial installation, Rotolock valves should be used, as they make service interventions on the compressor or on the cooling plant substantially easier and offer the possibility of simply fitting a high and low pressure switch. In this context, it is important that on a Rotolock valve the connection, located closest to the spindle, can be locked (connection option for the service pressure gauge). The other connection can be used for a pressure switch (connection not lockable).

As well as this on the compressor housing there are two further, smaller connection possibilities: a low pressure connection that can be used during commissioning or service, and oil equalisation connection that is only required in manifolding. In this parallel operation of compressors a size 10 copper tube as a compressor equalisation to the sister compressors equalisation fitted to the oil equalisation connection,
the suction line to the manifold compressors must be designed as symmetrically as possible and a non-return valve must be built into each individual discharge line.
The installation of the commercial (blue) reciprocating compressors should be done on rubber mounting grommets, as in the case of the black compressors.

**Electrical Connection**

If crankcase heating is to be fitted, with the PTC heater cartridge or a belt heater - there are two basic possibilities.
The PTC cartridge can be fitted very easily into the designated pocket at the base of the compressor and is self-regulating.
Consequently it can be constantly live and does not have to be switched off, if the compressor is running.

1: connect to mains - 2: earth - 3 and 4: knock outs for cable glands

The alternative belt heater on the other hand should only be activated when the compressor is idle. The blue compressors are mainly available on the market as three-phase devices in 400 V design. The electrical connection is relatively simple, as the compressors motor windings are already internally connected in the star point (joint of all three windings inside the compressor).
There are three connection pins, onto which the three phases coming from the contactor (or ideally from the motor protection in the switchboard) are directly fitted. Using a voltmeter you can check on the compressor terminal box that everything is in order with the power supply.
The mains (measured phase to phase) should always be around 400 V. As additional protection against excess temperature and against excessively high current loads, the commercial (blue) compressors have a bi-metal protection in the star point of the windings.
This means that it can be presumed that the internal motor protection has tripped, if in a resistance measurement on the compressor (disconnect supply voltage beforehand) an “infinitely large resistance” is measured between all three pins.
As soon as the compressor has cooled down again, the bi-metal protection switches on again.
If the electrical motor is ready for operation, then the three resistance values measured between the pins are approximately the same as each other. The value lies, depending on the size of the compressor, between 1 and 11 Ohm. The speed of these compressors at 50 Hz is the same as that of the smaller compressors, i.e. 2900 rpm.