Pressure regulators

Useful practical tips for the everyday work of fitters are provided in the “Fitters Notes” series. After dealing with the topic of condensing units in detail in the last section, now it is time to turn our attention to pressure regulators. Although the previously discussed components, such as throttle devices (expansion valves), evaporators (in connection with expansion valves), compressors and condensers (together with condensing units), are essential for an operational compressor-driven refrigeration system, it is not always necessary to use a pressure regulator, however it can help a lot to achieve the wanted performance.

Pressure regulators are necessary to regulate the pressure of certain components of the system. For example, an evaporating pressure regulator defines a certain minimum pressure in an evaporator, while a condensing pressure regulator does the same thing for a condenser. A crankcase pressure regulator prevents the system from exceeding a defined setpoint pressure, and a capacity regulator, which is also called a hot-gas bypass regulator, mixes in hot gas if the pressure on the low-pressure side drops below the setpoint pressure level. The purpose of a receiver pressure regulator is to initially bypass the condenser during system start-up in cold weather, after which it closes the bypass when a stable operating state is achieved. Another traditional element in large multi-evaporator systems with hot-gas defrosting is a differential pressure regulator. It maintains a constant, artificial pressuredrop between the hot-gas line and the liquid line during hot-gas defrosting. In this situation, the slightly higher pressure causes the hot gas fed into the evaporator to flow through the evaporator toward the liquid line and thus pass through the evaporator in a suitable volume.

Evaporating pressure regulator

Evaporating pressure regulators are fitted after evaporators (such as in a multi-evaporator system) that must be operated at a higher pressure than other evaporators. Evaporating pressure regulators are also often fitted to chiller units to provide additional protection against freezing of the water in the evaporator.

The Danfoss type code for low-capacity evaporating pressure regulators is ‘KVP’.

High-capacity evaporating pressure regulators consist of an ICS (or PM) main valve with a screwed-on pilot valve (type CVP 7).

The best way to adjust the setpoint pressure – below which the valve closes and above which it allows refrigerant to pass through (valve open) – is to use two low-pressure gauges. One of the gauges is connected to the suction (inlet) stub of the compressor, while the other is used to display the pressure between the evaporator and the evaporating pressure regulator. This one can be connected to the service port of the KVP, since this part has a 7/16” UNF measuring port on the inlet side. After this, the nominal value can be adjusted directly at the KVP with an Allen key. Turning the adjustment clockwise (in the + direction) increases the setpoint pressure, while turning it anti-clockwise (in the – direction) reduces the setpoint pressure. If the pressure drop increases when the setting is adjusted higher while the system is operating, it is sufficient to set the regulator to the desired regulator input pressure.

If you have only one low-pressure gauge available for measuring the evaporating pressure and increasing the setpoint value to the desired value while the system is operating results in a correspondingly higher evaporating pressure, the regulator is adjusted correctly. Caution is necessary if the actual evaporating pressure is higher than the desired setpoint value. Here it is not possible to directly adjust the setting without first taking other actions, since the regulator will always be open for any setpoint value below the actual value. In such a situation, the evaporating pressure must first be reduced. For example, this can be done with a fan-cooled evaporator by switching off the fan. The fan should be switched back on after the KVP has been adjusted.
Condensing pressure regulator

Condensing pressure regulators are used to prevent the condensing temperature in a refrigeration system from dropping too low, especially during cold weather. They can be fitted in the hot-gas line downstream of the T-fitting branch to the receiver pressure regulator or in the condensate line.

A check valve must always be fitted in the condensate line if the regulator is fitted in the hot-gas line, as otherwise refrigerant could flow back into the cold condenser and the desired effect of a rapid pressure increase before the expansion valve would no longer be assured during winter start-up. The most commonly used option is to fit the condensing pressure regulator in the condensate line (between the condenser and the receiver).

A KVR regulator is used in relatively low-capacity systems. A condensing pressure regulator for a high-capacity system is almost the same as an evaporating pressure regulator. It consists of an ICS (or PM) main valve with a screwed-on pilot valve (type CVP 28 or CVP 22 for R1 34a). The number after 'CVP' stands for the maximum control pressure of the pilot valve, in this case 28 bar or 22 bar. It is hardly surprising that the components necessary for the evaporating pressure and condensing pressure regulators are similar, since in both cases the objective is to define a certain minimum pressure that must be maintained. The two applications differ only in the overall pressure level.

For adjustment, it is at least necessary to connect a high-pressure gauge to the inlet-side measuring port of the KVR. The best results can be obtained by connecting an additional high-pressure gauge to the receiver. The rest of the procedure is the same as for the KVP evaporating pressure regulator.

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Crankcase pressure regulator

A crankcase pressure regulator is desirable if the system compressor (often a freezer compressor) must be protected against excessively high pressure. The regulator is fitted in the suction line. Crankcase pressure regulators have fallen somewhat out of fashion in the last while with the use of individually (electronically) adjustable MOP points in systems with electronic injection control. Nevertheless, they still hold their own as traditional pressure regulators. The Danfoss type code for directly controlled pressure regulators for relatively small refrigeration systems is ‘KVLForlargersystems,itisrecommendedto use an ICS (or PM) main valve with a screwed-on pilot valve (type CVC). A branch line must also be routed to the CVC pilot valve from the main line downstream of the main valve. This supplies the actual value of the pressure between the valve and the compressor, which is the controlled parameter, to the crankcase pressure regulator.

Adjusting a crankcase pressure regulator is only difficult in cases where the suction pressure is very low. There are no simple solutions in such cases. However, as this usually occurs with freezer systems, it may be possible to use defrost heating to increase the suction pressure. Another option is to set the freezer cell temperature to a higher value than the normal operating value. This is usually not difficult during construction.

Capacity regulator

Capacity regulators are often used in systems where it is necessary to compensate automatically for partial-load periods. This is based on the principle that the suction pressure drops when the amount of heat ente-
ring the evaporator is less than under full load. This means that the setpoint value of a hot-gas bypass system is set slightly lower than the suction pressure at full load under stable operating conditions. If the suction pressure decreases, the relationship between compressor and evaporator cooling capacities shifts in favour of the compressor, and the capacity regulator opens and allows hot gas to flow from the high-pressure side to the low-pressure side. This mass flow prevents any further drop in the suction pressure. The investment cost of such a solution is low compared with the combination of a compressor-pack regulator plus a pressure transducer and compressor-pack system. In the latter case, suction pressure stabilisation is achieved by switching compressors on and off. A disadvantage of the hot-gas bypass control arrangement is its energy consumption. There are two sorts of hot-gas bypass regulators in terms of the operating principle. In systems with a single evaporator, the bypass regulator is located in the injection line (between the expansion valve and the evaporator), while in systems with more than one evaporator, hot-gas regulation is applied to the suction line. Most systems of the latter type are fitted with injection for cooling down the refrigerant temperature to an acceptable level in front of the compressor.

Danfoss provides the CPCE regulator and LG hot gas mixer for capacity regulation in the injection line of relatively low-capacity systems. This device has a separate port for connecting a branch line originating from the suction line. As a result, the actual suction pressure is always available to the regulator as the actual value and control input, despite the pressure drop over the distributor ahead of the evaporator. This additional port is not present with the KVC part, which is used for direct feed into the suction line in relatively low-capacity systems. For larger capacities, an ICS (or PMC) main valve with a screwed-on pilot valve (type CVC) is the right choice for both applications.

A low-pressure gauge is necessary for adjusting the hot-gas bypass regulator. A low evaporating pressure setpoint value is ideal for adjusting the setting. In this case, the bypass regulator can be adjusted directly to the desired value. The flow noise provides a clear indication of whether bypass is occurring.

If the evaporating pressure is too high, the same measure as described under ‘Evaporating pressure regulator’ must be taken. Another small remark regarding the injection valve is in order here if the bypass is routed directly to the suction line. There are conventional injection valves available that are designed to have the sensor fitted on the pressure side of the compressor. However, it is also possible to use a normal expansion valve with internal pressure equalisation as a injection valve. For this purpose, it is only necessary to adjust the superheating setting to a higher level and fit the sensor to the suction side ahead of the compressor. A practical rule of thumb is 15 K. With the standard factory setting of a normal type T2 expansion valve (7 K), the superheating adjustment spindle must be rotated by two complete turns (360°) in the clockwise direction. This prevents the injection valve from interfering with the normal expansion valve while still ensuring that the intake temperature at the compressor does not rise too high.

**Receiver pressure regulator**

Receiver pressure regulation is normally used in combination with condensing pressure regulation. A receiver pressure regulator is necessary for bypassing the condenser for system start-up in the winter and blocking the bypass when the normal operating state has been reached. This measure results in rapid pressure build-up ahead of the expansion valve, even during winter start-up. A receiver pressure regulator thus avoids undesirable system shutdowns triggered by the low-pressure switch under cold weather conditions.

Danfoss offers the NRD and KVD regulators, as well as the ICS (or PM) main valve with CVPP differential pressure pilot valve for high-capacity systems. There are fundamental differences between the NRD and KVD, although both types are designed for receiver pressure regulation. For instance, the NRD regulates the pressure based on the differential pressure, which is set to a fixed value of 1.5 bar by its construction, while the KVD works on the basis of the outlet pressure. The outlet pressure setpoint is user adjustable. If the setpoint value of a KVD regulator is higher than the actual pressure on its outlet, it allows the refrigerant to flow through. With the NRD regulator, a differential pressure of approximately 1.5 bar must be exceeded before the regulator valve opens. Due to its fixed setting, the NRD cannot be adjusted or set to a different value. As adjusting the setpoint of a receiver pressure regulator is not especially easy, especially during the summer, it is recommended to use the NRD. If the possibility of making individual adjustments or a somewhat larger capacity is desired (the kv value of the KVD is approximately twice that of the NRD), the KVD is the best solution. Adjusting the KVD to the correct setting is best performed during winter operation. For this purpose, first start up the refrigeration system and then wait until the pressure has built up on the high-pressure side. The bypass point of the KVR evaporating pressure regulator must always be set higher than the closing point of the KVD. This way the KVR remains closed, and the KVD threshold value can be set around 1 to 2 bar lower than the KVR while the

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system is starting up. The KVD must first open so that it can close later when the receiver pressure approaches the operating point or the opening point of the KVR. If the system is initially put into service in the summer, the factory setting should be used and then adjusted appropriately. The factory setting is 10 bar, and the setpoint can be increased by 2.5 bar for each 360-degree rotation in the clockwise direction. There is nothing wrong with this, since makes no real difference in principle whether the KVD receiver pressure regulator operates at 1 bar or 2 bar below the KVR level.

**Differential pressure regulator**

Besides receiver pressure regulation, there is also another application for differential pressure regulation. This involves systems with hot-gas defrosting, because in such systems the hot gas must flow through the evaporator toward the liquid line during defrosting. It must also be possible to disable this artificial differential pressure when the system is not operating in defrost mode.

In this case, it is recommended to use an ICS (or PM) main valve with a CVPP differential pilot fitting, as already mentioned. In order to disable differential pressure regulation, which is not necessary in receiver regulation operation, an additional pilot is necessary: an EVM solenoid valve for direct fitting to the ICS (or PM). If the two pilot valves – CVPP (don’t forget the branch line to the main line downstream of the valve) and EVM – are fitted to an ICS designed for a maximum of three pilot valves, the differential pressure function of the CVPP will be active when the EVM is closed (EVM mounted on one of the “S” ports, CVPP mounted on “P” port of the ICS/PM or vice versa). When the EVM is open, operation with (elevated) differential pressure is disabled. The EVM solenoid valve must be closed for adjusting an ICS main valve fitted with CVPP and EVM valves. Here you must be careful, because these pilot valves are available in two versions: closed when de-energised and open when de-energised. For example, a EVM that is closed when de-energised (type NC) is closed when no power is applied to the coil. When the solenoid valve is closed, the differential pressure can be adjusted directly while the system is operating after two high-pressure gauges have been connected ahead of and after the control valve. The compressor discharge stub can be used as the measuring point in the upstream direction of the valve, or better yet, the gauge port on the side of the ICS valve (which is always at the valve inlet pressure). A measuring point on the condenser or receiver can be used on the downstream side of the valve, or a suitable T-nipple on the branch line to the CVPP can be used.

**Identification with existing systems**

Many times you will encounter the problem that a Danfoss KV regulator is already installed in a system and it is no longer possible to determine the actual type from the label. You can use the following trick in such cases. First check whether the device is installed on the high-pressure side, on the low-pressure side, or between the high-pressure and low-pressure sides. If the KV regulator is installed between the high-pressure and low-pressure sides, it is unquestionably a KVC capacity regulator. If it is on the high-pressure side, it can be either a KVR or a KVD, and on the low-pressure side either a KVP or a KVL. The next important factor is the orientation of the adjustment spindle. The adjustment spindle (the spindle inside the end piece of the regulator) always points in the direction to be regulated.

This means that the imaginary extension of the adjustment spindle of a KVP evaporating pressure regulator always points toward the evaporator, while with a KVL crankcase pressure regulator it always points toward the compressor. A KVR condenser regulator, by contrast, always points toward the condenser unless it is installed in the hot-gas line (in which case it faces toward the compressor), while a receiver pressure regulator always points toward the receiver.

**Restoring the factory setting and preset values before putting the system into service**

When a KV regulator is identified in an existing system, there is a very useful way to restore the factory setting. Starting from the factory setting, it is easy to adjust the regulator to the desired setpoint by suitable rotation of the adjustment spindle. The setpoint value can be deduced directly from the distance between the inner spindle of the pressure regulator and the top of the regulator housing. Consult the table below for this purpose.

<table>
<thead>
<tr>
<th>Type</th>
<th>Factory setting</th>
<th>X mm</th>
<th>bar/turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>KVP 12-15-22</td>
<td>2 bar</td>
<td>13</td>
<td>0.45</td>
</tr>
<tr>
<td>KVP 28-35</td>
<td>2 bar</td>
<td>19</td>
<td>0.30</td>
</tr>
<tr>
<td>KVP 12-15-22</td>
<td>2 bar</td>
<td>22</td>
<td>0.45</td>
</tr>
<tr>
<td>KVP 28-35</td>
<td>2 bar</td>
<td>32</td>
<td>0.30</td>
</tr>
<tr>
<td>KVP 12-15-22</td>
<td>10 bar</td>
<td>13</td>
<td>2.5</td>
</tr>
<tr>
<td>KVP 28-35</td>
<td>10 bar</td>
<td>15</td>
<td>1.5</td>
</tr>
<tr>
<td>KVP 12-15-22</td>
<td>10 bar</td>
<td>21</td>
<td>2.5</td>
</tr>
<tr>
<td>KVP 12-15-22</td>
<td>2 bar</td>
<td>13</td>
<td>0.45</td>
</tr>
</tbody>
</table>

You can use the information in this table to quickly preset all types of KV regulators. In many cases, this is sufficiently accurate and it is not necessary to make any further adjustment after checking with a pressure gauge.
Subject of the next issue: pressure switches

Now you have learned about pressure regulators and their many possible uses. The next article in the Fitters Notes series will deal with pressure switches. If you are interested in this topic, read more about it 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).