Thermostats

Fitters Notes (Part 7)

In the last issue we discussed the subject of pressure switches, and now we turn our attention to thermostats. Commonly used thermostats resemble pressure switches in various regards, such as that a potential-free contact system is normally used. The most common application for thermostats is room temperature control, in which regard it does not matter whether this involves a cold room, a cooling cabinet for liquor, or even a simple refrigerator.

The tasks of a thermostat – room temperature control
You could almost go so far as to say that the unofficial fifth main component of a refrigeration system – aside from the compressor, throttling device, condenser and evaporator – is the thermostat. This is because even with the simplest compressor refrigeration systems, such as a household refrigerator, a thermostat is always used to control the temperature inside the refrigerator. In this case, the thermostat either switches the compressor on and off directly or switches a contactor or relay. As an alternative, the solenoid valve can be switched directly if pump-down or pump-out circuits are used. This arrangement can be used to avoid a high contact load, such as would result of the compressor load were switched directly by the thermostat. If it is not desired to fit a solenoid valve in the liquid line of the system, it is naturally not possible to use this circuit option. Using a thermostat to control the room temperature assumes that the system is a type where the evaporator chills the air.

Water and brine temperature control
If the evaporator chills cold water or brine instead of air, the thermostat can be used to control the temperature of the liquid. A control thermostat of this sort is usually installed in the return line (the water returns from the load, for example a water-chilled chest, to the evaporator). In such cases, a supplementary thermostat (frost protection thermostat) is usually present in the feed line. Along with the flow switch, it prevents the system from dropping below a certain threshold level that could lead to icing of the water circuit and thus to cracking of the evaporator or other components due to ice pressure. This is a risk because the volume of water increases by around 10% when its state of aggregation changes from liquid to ice, so water inside a closed system can easily cause considerable damage. Of course, it is still possible to use a room thermostat even with cold-water systems, if the room is cooled by water-chilled chests.

Defrost limiting
Getting back the actual subject of refrigeration technology, another standard application for thermostats is as a defrost thermostat. To avoid unnecessary energy consumption, the duration of the defrost cycle can be controlled very precisely by a thermostat whose sensor is preferably located in the most persistent ice pocket of the evaporator. This provides a clear energy advantage relative to time-controlled defrosting with the system always defrosted for a specific, pre-defined length of time, regardless of whether the evaporator is already free of ice. In this connection, an even better solution is defrost on demand, although this cannot be implemented using a simple thermostat. It requires more elaborate electronics that can decide whether defrosting has to be started, based on stored system characteristic curves. However, here you should bear in mind that even if this function is called “defrost on demand”, specific time windows should be defined in advance. This can be used to prevent performing a defrost cycle during restocking or just before restocking.

Compressor discharge monitoring thermostats
Discharge thermostats are somewhat rare. The purpose of this application is to protect the compressor against excessively high discharge temperatures. It also protects the refrigerating machine oil against excess heat load and thus against denaturing. Particularly in systems that use scroll compressors, this protective measure is relatively common. However, it is also advisable for systems with piston compressors.
Danfoss thermostats in the KP series are basically available with two different sensor media. In order to decide which medium and which device is suitable for a particular application, it is important to know the difference.

The one type is a vapour medium, while the other type is an adsorption medium. The most important difference is that with the vapour medium the sensor must always be placed in a location that is colder than the KP enclosure. This is due to the fact that a certain volume of liquid is available for vaporisation inside the sensor. When it vaporises in the sensor, the pressure in the sensor system increases and the pressure bellows expands, which in turn actuates the contact system. However, if this liquid migrates to the thermostat enclosure, it can no longer vaporise in the sensor and the thermostat does not operate as intended. This phenomenon is similar to conventional refrigerant migration, in which the refrigerant always collects in the coldest part of the system. If an adsorption medium is used, it does not matter whether the sensor temperature is higher or lower than the temperature of the associated enclosure.

Refrigerator thermostat

The second main form of construction is the conventional refrigerator thermostat. It is used as a room thermostat for refrigerators, but it is also frequently used for relatively small bar refrigeration systems and similar applications. The advantages of refrigerator thermostats are that they have a very moderate price and long service life. If the thermostat must be replaced when servicing the system, pay attention to the following points. Refrigerator thermostats are available in many different versions, but they differ in only a few details. These are the length of the capillary tube, the temperature switching points, whether an automatic defrost or constant restart temperature is present in the positive temperature range, and whether an auxiliary signal must be switched in parallel to or opposite to the working sense. For this reason, you only need to have a few service thermostats on hand to cover service needs, which makes things considerably easier. Danfoss has eight service thermostats, which can be used to replace the vast majority of refrigerator thermostats if repairs are necessary, thanks to their extra-wide temperature range and long capillary tube. The number 3 and number 8 thermostats are especially important for refrigeration system builders. Service thermostat no. 3 is suitable for refrigerators with automatic defrosting or a constant restart temperature, which is the most common type in present use. Service thermostat no. 8 is important for small refrigeration systems, because it is commonly used in beverage vending machines and liquor chilling cabinets in the restaurant industry. However, it only covers the upper evaporating temperature range. These thermostats are also good for regulating the temperature of salad bars. Of course, there are also other basic types of mechanical thermostats. However, here we only wish to describe the most important forms of construction that are used in refrigeration systems.

Sensor types

There are also different types of sensor construction for different thermostat applications, which are optimised for the corresponding intended use. Thermostats for measuring the actual room temperature usually have a fixed spindle fitted below the thermostat (type KP or RT). For use as an evaporator thermostat, it can be fitted with a simple capillary tube sensor or a cylindrical remote sensor with a capillary tube connection to the main device. The cylindrical remote sensor is recommended for pipe mounting, such as for compressor discharge temperature monitoring mounted at the pipe direct after the discharge connection of the compressor. There are also special duct sensors for monitoring or controlling the temperature in a ventilation duct.
Contact rating
An important consideration for using thermostats with potential-free contacts is the contact rating. As mentioned in the article on pressure switches in the previous issue, manufacturers usually specify contact ratings for three different types of loads. These load types are also applicable to thermostats, so a brief summary is in order here.

The three different ratings are for purely resistive loads (in which case the maximum contact load is conventionally possible), partly inductive loads, and purely inductive loads. An electrical resistance heater for defrosting is an example of a resistive load (load designation: AC 1). This load type must be used when you are selecting a defrost thermostat that is connected directly to the heater. An example of a partly inductive load (AC 3) is an electric motor. Naturally, this class also includes a compressor that is switched directly by the thermostat. By contrast, a coil (AC 1 5) – such as the coil of a solenoid valve – acts as an inductive load on the contact system of the thermostat.

Electrical connection
A standard KP thermostat with changeover contacts usually has three terminals for connecting the conductors of an electrical cable. This is similar to the contact assignments with KP pressure switches.

The terminals are for "phase in" (contact marking: 1), "heating action" (contact marking: 2), and "cooling action" (contact marking: 4). If only two contacts are used, the conductors can be connected to the "phase in" (contact 1) terminal and the "cooling action" (contact 4) terminals either way round. The "heating action" terminal (contact 2) is rarely used in refrigeration systems. An example of a situation where it is used is when reheating must be used for a particular reason. For instance, it could be used to control an electric heater. In specific terms, with a Danfoss KP6 1 thermostat the "phase in" conductor is connected to contact 1 and the "cooling action" conductor is connected to contact 4.

Setting
Type KP thermostats for wall- or bracket mounting have the following setting options. There are two individually adjustable scales on the front of the device. The scale on the left is for the setpoint value, while the scale next to it on the right is for the difference setting (hysteresis). Adjust the setting of the left scale to the upper switch point and the scale next to it to the difference. The switch-off point is equal to the upper switch point minus the difference. If the electrical cable is connected to contacts 1 and 4, the circuit will be switched on at the value set on the left scale (for example, the compressor will be switched on) and switched off at this value minus the difference set on the scale to the right. Example: a left-hand value of –10 °C with a right-hand value 6 °C corresponds to a switch-off value of –16 °C. As the thermostat is a mechanical component, the difference value is never exactly the same. It depends on the actual switch point setting. The exact difference value can be determined either experimentally with the system (observing the actual switch points) or by using a suitable nomogram (included with the instructions for the KP thermostat). In actual practice, the method of calculating the switch-off point as the left-hand value minus the difference on the right-hand scale is usually sufficient.

IP protection rating
The IP protection rating can be an important consideration, depending on local circumstances and ambient conditions. A brief introduction to IP: the first digit of the two digits of the IP rating (e.g. "IP54") describes the degree of protection against penetration, while the second digit describes the degree of protection against water. An IP rating of IP3x means that it must not be possible for a wire with a diameter of 2.5 mm to penetrate into a device with this certification. IPx3 means that the device is suitable for use with falling water spray at an angle of up to 60° from the vertical. Generally speaking, the higher the protection rating, the better the device is protected against dust, dirt particles and moisture. Standard KP thermostats have an IP33 protection rating with regard to the effects of dust and moisture. The IP55 level can be achieved by using an accessory protective enclosure. If an even higher IP protection rating is desired, you can use the RT series, which is designed for especially harsh environments. These devices have an IP protection rating of 54 to 66, depending on the model.

Electronic thermostats and cold room controllers
Up to now we have only discussed mechanical thermostats. With regard to reliability, robustness and simplicity, such thermostats have an established position in refrigeration systems and will maintain this position in the future. Nevertheless, in some cases it can be worthwhile to use an electronic thermostat or cold room controller. These devices often offer advantages, especially due to the combination of functions such as room temperature control with defrost limiting and room temperature display, which are offered by all commonly available electronic cold room controllers. In
addition, an electronic thermostat may be chosen due to the desire for specific hysteresis values, since it is not always possible to configure any desired hysteresis value (switching difference) with a mechanical device.

**Preview of the next issue:**

**Electronic evaporator injection systems**

This concludes our discussion of the topic of thermostats. In the next article, we will discuss electronic expansion valves and electronic evaporator injection.

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**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).