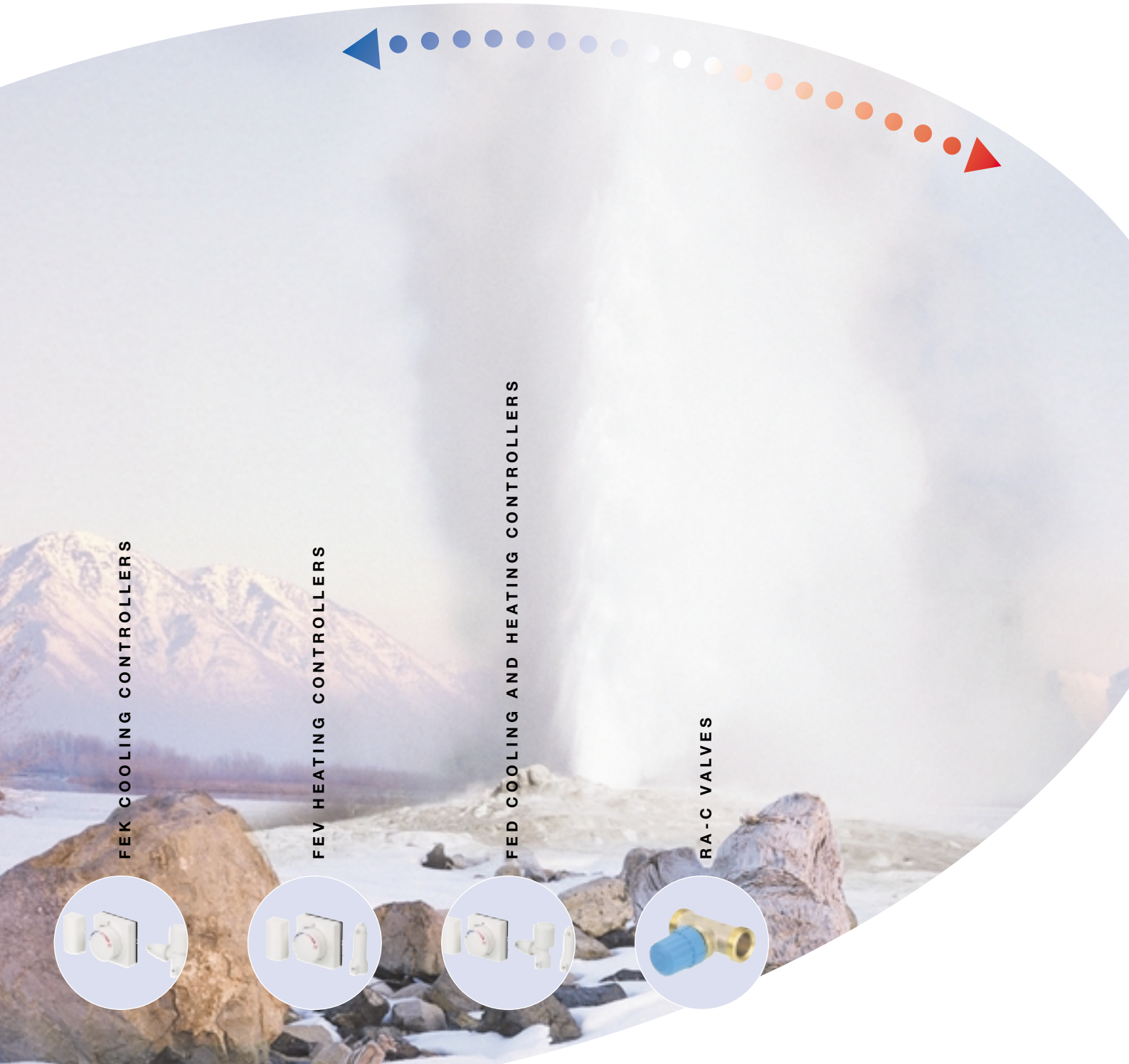
REGULATION FOR HYDRONIC COMFORT COOLING SYSTEMS

APPLICATION GUIDE



REGULATION FOR HYDRONIC COMFORT COOLING SYSTEMS

Product & application guide for Danfoss self-acting climate controllers

Table of contents:

1. Introduction

Indoor climate & work efficiency

The focus on and demand for better indoor climate is increasing, partly because more and more people are working indoors, and partly because indoor climate influences people's well-being and thereby their efficiency at work. Two factors in particular have a critical impact on work productivity and efficiency:

1. **Air quality**
   e.g. avoiding sick building syndrome (studies by P. O. Fanger[1] have demonstrated this relationship).

2. **Room temperature**
   (studies by David Wyon[2] have demonstrated this relationship).

[1]) P. O. Fanger:
Indoor climate in the 21st century, VVS/VVB 5/2000

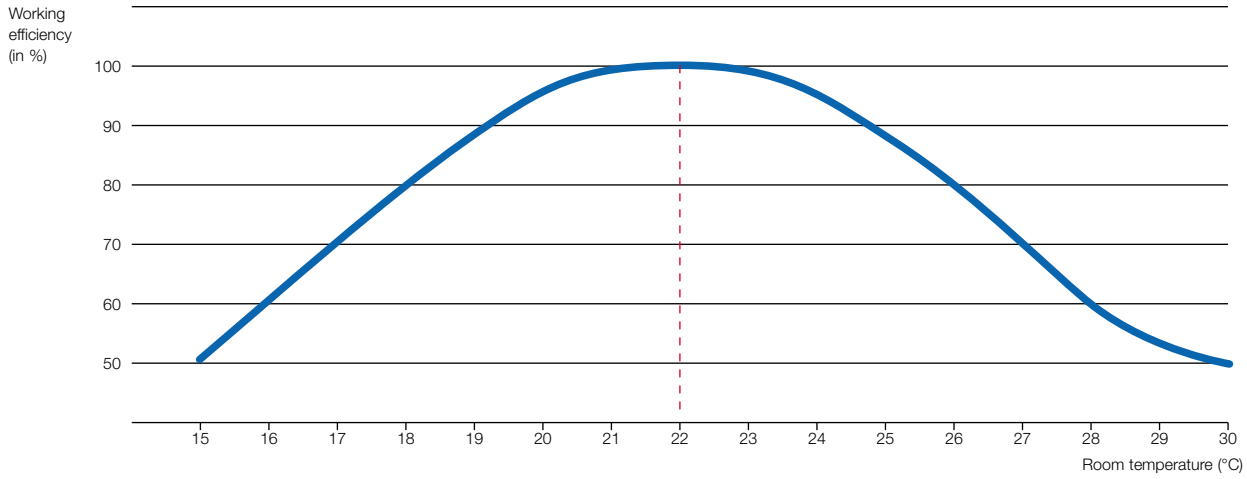
[2]) David Wyon:
Statens Institut för Byggnadsforskning, Sweden

[3]) Depends also on factors like Clo, Met, etc.

The figure below (based on the findings of David Wyon) illustrates that a person's working efficiency on an average is at its highest when the room temperature is 22°C, and rapidly declines when the room temperature is either too high or too low[3]. The cost of operating a comfort cooling system is often less than 1% of the wages paid per year, which means that installing a comfort cooling system pays for itself quickly. This is achieved through increased productivity and efficiency and fewer illness-related absences among the employees.

The figure below also shows that reliable, individual room temperature controllers are essential for providing high comfort through maintaining a constant room temperature around 22°C.

Employee working efficiency in relation to office temperature



Types of comfort cooling systems

Comfort cooling systems can be classified into 3 different system types, depending on the heat carrier:

System	Heat carrier	Terminal unit
Direct expansion systems	Refrigerant gasses	Room air conditioners, split unit, multi-split, fan coils
Indirect expansion systems	Air	CAV unit, VAV unit
Indirect expansion systems	Water (e.g. with some kind of brines)	Chilled beams, chilled panels, fan coils, induction units

Danfoss supplies climate controllers for water-based/hydronic comfort cooling systems.

The advantages of using water-based/hydronic systems include the following:

1. They ensure an environmentally responsible solution, due to their minimal use of refrigerant gasses.

2. Water is a much better heat carrier than air. Much more air (and therefore larger duct work) is needed to provide the same cooling effect as water.

3. In larger buildings the operating costs of using hydronic comfort cooling systems are lower than direct expansion systems.

Purpose

This application guide is intended to provide an introduction to Danfoss new self-acting controllers, as well as to suggest various system applications, where Danfoss controllers are recommended.

The new self-acting controllers ensure exact room temperature regulation of the following terminal units:

- Chilled beams (active and passive)
- Chilled panels
- Fan coils
- Induction units

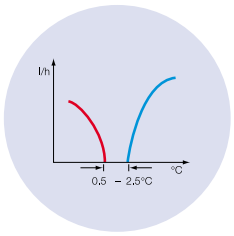
Renovation Project in Stockholm, Sweden

Building:	Akademiska House
Room construction:	Office building. Both open and cell offices
Danfoss controllers:	FEK-IF and RA-C 15 valves operate the cooling circuit
Cooling emitter:	2-pipe chilled beams from ESSEN
Heating installations:	2-pipe radiators with thermostats

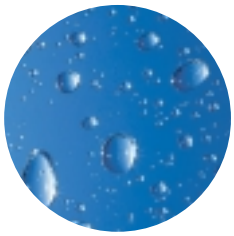
New Construction Project in Horten, Norway

Building:	Townhall in Borre
Room construction:	Office building. Both open and cell offices
Danfoss controllers:	FED-IF and RA-C 15 operate both the heating and cooling circuits
Cooling emitter:	2-pipe ventilated chilled beams from Halton/Acti-Com
Heating installations:	2-pipe radiators

1.1 Definitions



Sequential control function



Hydronic systems

The terminology used within the comfort cooling market is highly diverse and varies considerably from one country to the other – not to mention the sheer number of words used. What follows is a list of important terms and their definitions:

Climate controllers:
Controllers that regulate room temperature by regulating heating and/or cooling circuits.

Sequential controllers:
Controllers that regulate heating and cooling circuits sequentially. They activate either the heating circuit or the cooling circuit, and ensure (by means of a neutral zone) that heating and cooling circuits are never running at the same time.

Comfort cooling systems:
Systems that are installed to maintain and secure a comfortable temperature in a room where people work, etc. The systems are activated to provide a high level of thermal comfort.

Comfort cooling systems are used in commercial buildings – e.g. banks, small production facilities, hotels, showrooms, office buildings, institutions, etc.

Thermal comfort:
Defined in the ISO 7730 standard as being "That condition of mind which expresses satisfaction with the thermal environment". Temperature is one of the vital parameters that influences a person's thermal comfort level. If a room is too hot, the person will feel discomfort, or if the skin temperature falls below 34°C, the human cold sensors begin to send impulses to the brain and the thermal comfort level decreases.

Hydronic system:
In hydronic comfort cooling systems the heat carrier is either pure water or water mixed with some kind of brine (often glycol). Hydronic systems are also called water-based or radiant systems.

Piping systems:
There are many ways of arranging the pipe installations in a comfort cooling system. Normally, 2 or 4-pipe systems are installed. However, 2-pipe changeover systems are also used. In section 3 in this guide – "Application overview" – the various piping systems are illustrated.

Fan coils and induction units:
A fan coil unit is a heating and/or cooling ventilated/hydronic emitter with an incorporated fan for air circulation. Hot and/or chilled water is led to the fan coil's heat exchanger, and the air is circulated through this exchanger before it is sent into the room. The fan coil can be placed on the floor, mounted on the wall or built in to the ceiling. In controlling a fan coil, regulation for both the room temperature and the speed of the fan is needed.

The induction unit is similar to the fan coil but is supplied with fresh air from a central air-handling unit (AHU). The air volume is regulated by the design of the air nozzles. In regulating the induction unit, only a controller for room temperature is needed.

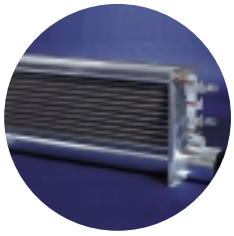
Chilled ceilings:
Chilled ceiling terminology covers both chilled panels and chilled beams.

A chilled panel can be compared to a floor heating system, but is installed in the ceiling. The chilled water runs through the pipes and thereby lowers the temperature in the room. This type of cooling is based on radiant cooling (also known as still cooling) because no ventilation is connected directly to the chilled panels.

Chilled beams can be divided into active and passive beams, depending on whether they are supplied with fresh air or not. A passive chilled beam allows the rising warm air to pass through the beam. The air is cooled by the beam's cooling surface and will then be circulated downwards. An active beam is like a passive beam, but it is also supplied with fresh air from a central ventilation unit.

2-pipe and 4-pipe chilled beams are available on the market.

Fan coil



Induction unit

Chilled panel

Chilled beam

2. Controller equipment

Danfoss has two types of controller equipment for regulating room temperature in a comfort cooling system:

- **Self-acting controllers**
- **Electronic controllers**

These two very different types of automatic controller equipment are suitable for a wide range of terminal units. The controllers are used in all kinds of hydronic systems, often in large systems with a buffer, where water is circulated in the secondary system.

The focus in this product and application guide will be on Danfoss self-acting climate controllers. However, the complete Danfoss product range, which applies to comfort cooling systems is presented at the end of this guide in section 5, "Danfoss products for comfort cooling systems".

2.1 Self-acting climate controllers

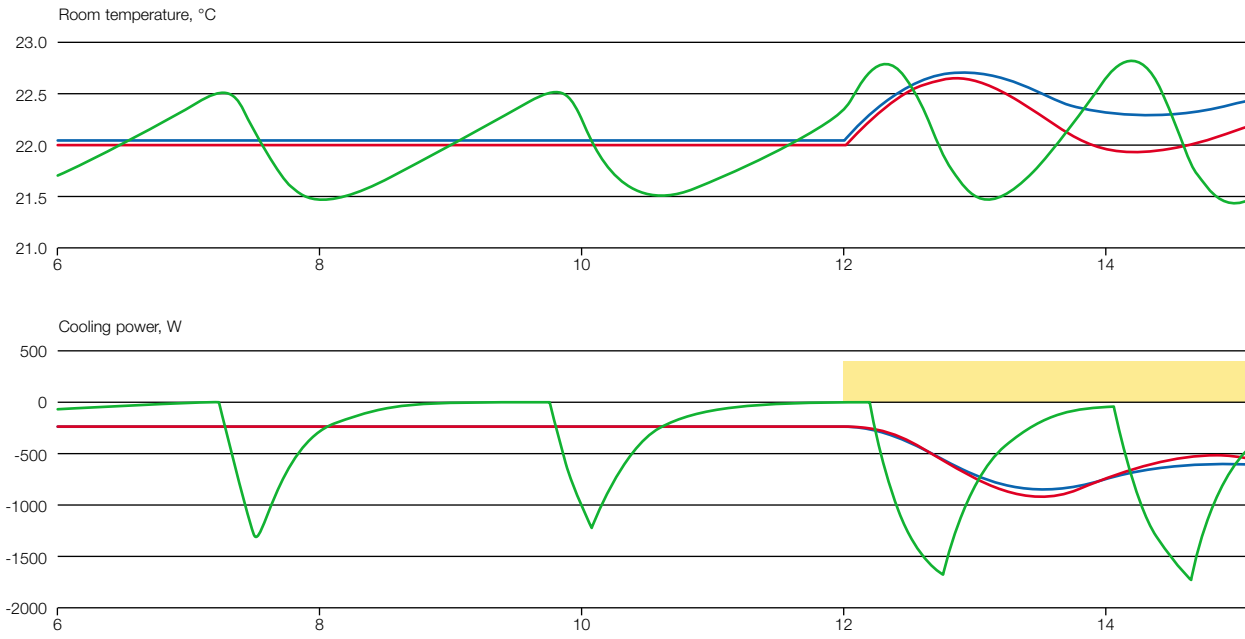
The self-acting climate controllers are based on the same self-acting principle as the Danfoss thermostat, i.e. on the natural principle that the volume of the liquid will increase and decrease depending on room temperature changes.

Danfoss controllers consist of a bellows system. The controller is actuated by ambient temperature changes and will, via the liquid volume, control the water flow through the valve. Danfoss controllers are proportional controllers (P-controllers).

2.1.1 Regulation theory

The objective of climate controller is to minimize the difference between the actual/controlled room temperature and the end-user defined set point temperature. For example, if a person desires the room temperature to be 22°C, this would be the set point, and the aim of the controller is to regulate the valve and the water flow so that the temperature remains at 22°C under all workloads.

There are different kinds of controller solutions for regulating room temperature in a comfort cooling system. On/off, P or PI controllers are often used to regulate fan coils, induction units, chilled beams and chilled panels.



The on/off controller is the most simple. It has only two stages: "on" (valve fully open – full flow of water) or "off" (valve fully closed – no water flow). An on/off actuator takes 3-5 min. to open and close the valve, and therefore provides least stability in the room temperature. This is illustrated in the figure below.

The P controller is modular, which means that it can adjust the opening-degree of the valve and the water flow continuously. The P-controller is associated with a P-band, often in the area of 1-2°C – which is an acceptable offset to the set point temperature. The P-controller ensures a stable control and continuous water flow.

The PI controller is a P controller with an I-element that removes the offset from the set point temperature over time. However, in the cooling season when cooling is only required for part of the day, there is actually little or no difference between P and PI control.

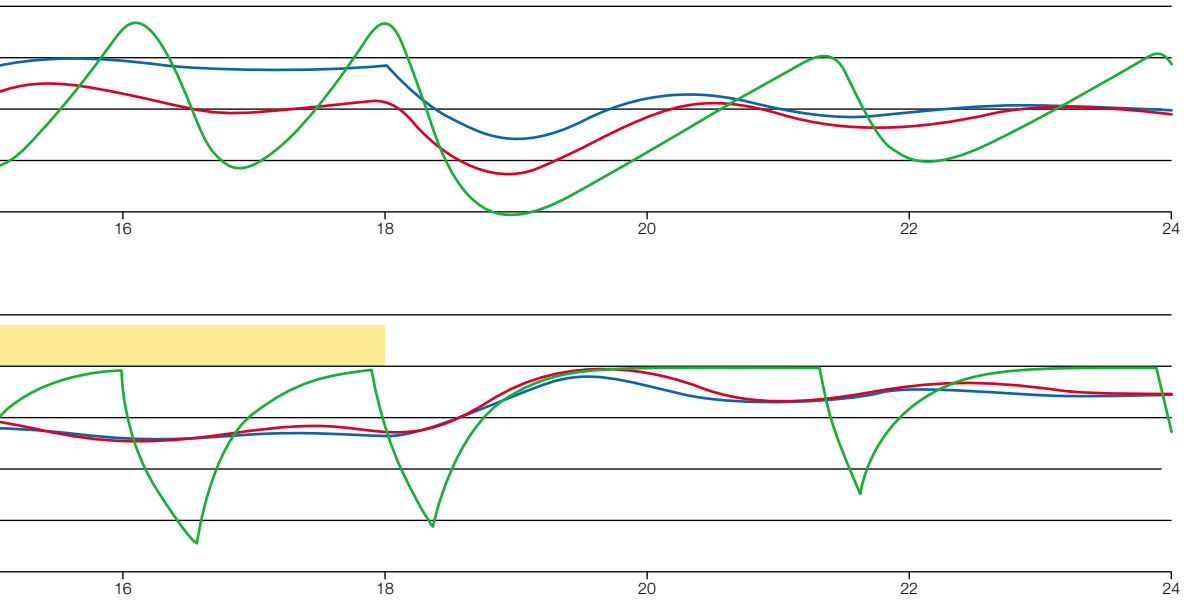
The figure illustrates room temperature deviation from set point (here 22°C), based on on/off, P and PI controller solutions. It also illustrates the impact of an increased heat load in the room of 400 W (e.g. from sun infiltration) during the period 12.00-18.00 o´clock, and the impact of this on the three controller types.

It can be concluded that:

- A P-controller might show a slightly higher deviation from the set-point temperature than a PI-controller when the heat load is changed in a room.
  However, the two controllers' reaction patterns are quite similar, and the thermal comfort level for the person in the room will most likely be the same whether a P-controller or a PI-controller is used.

- If a P-controller is compared to an on/off controller, it is clear that the P-controller solution will provide a higher degree of comfort, because the P-controller is able to maintain a more stable temperature level in the room. Moreover, the fact that an on/off actuator will open and close the valve more often than a P-controller solution might have some influence on the noise level in a comfort cooling system.

Danfoss self-acting P-regulated climate controllers constitute an attractive alternative to electronic controller solutions with PI or on/off regulation. Danfoss self-acting climate controllers ensure a constant room temperature and a high level of comfort for the people in the room.



<····· *Set point (22°C)*

On/off controller

PI controller

P controller

Sun infiltration

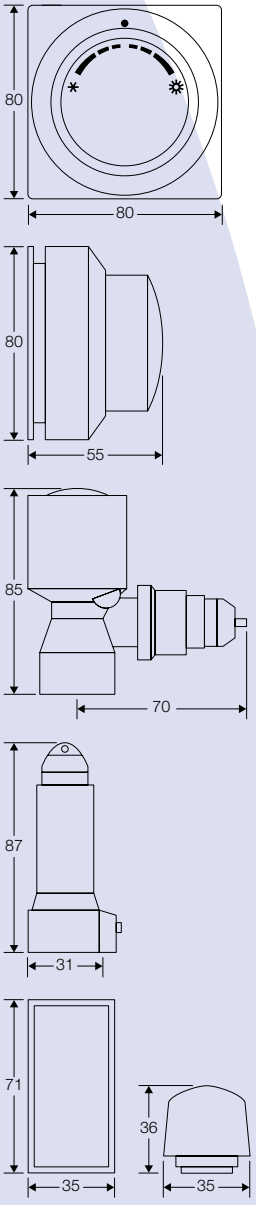
Source: Based on simulated data from Simulink programme.

2.2 Self-acting climate controller product range

Danfoss has developed a complete range of controllers for regulating heating, cooling and sequential heating/cooling systems.

The controllers are used in comfort cooling systems installed in new buildings, but can also easily be used in renovation projects (e.g. in existing buildings where new additional cooling systems are to be installed).

The self-acting climate product range includes the FED, FEK, FEV and RA-C.



2.2.1 FED
for sequential heating/cooling circuits

FED-FF (013G5462)

A sequential controller for heating and cooling circuits including remote setting sensor.
Capillary length 2 + 2 + 2 m.

FED-IF (013G5463)

A sequential controller for heating and cooling circuits with integrated remote setting sensor. Capillary length 4 + 11 m. (013G5461: with capillary length 7 + 8 m).

FED sensors are used in applications in which a cooling and a heating circuit are to be regulated by one controller. The neutral zone prevents the system from heating and cooling at the same time, avoiding any unnecessary heating and cooling consumption. The neutral zone can be adjusted from 0.5-2.5°C – also depending on the differential pressure in the system.

The FED controller can be used for 2-pipe changeover systems. 4-pipe beams, radiator and chilled ceiling solutions,4-pipe fan coils and 4-pipe induction units.

Temperature adjustment range: 17-27°C. It is easy to limit or lock the temperature setting by means of the built-in limiting device.

2.2.2 FEK
for cooling circuits

FEK-FF (013G5464)

A controller for cooling circuits including remote setting sensor.
Capillary length 2 + 2 m.

FEK-IF (013G5465)

A controller for cooling circuits with integrated remote setting sensor. Capillary length 5 m.
(013G5468: with capillary length 8 m).

FEK controllers are installed in rooms that have a heat surplus due to internal or external heat sources; i.e. only regulation of the cooling circuit is needed.

The FEK can be used for 2-pipe systems, such as chilled beams, chilled panels, fan coils or induction units.

Temperature adjustment range: 17-27°C. It is easy to limit or lock the temperature setting by means of the built-in limiting device.

2.2.3 FEV
for heating circuits

FEV-FF (013G5466)

A controller for heating circuits including remote setting sensor.
Capillary length 2 + 2 m.

FEV-IF (013G5467)

A controller for heating circuits with integrated remote setting sensor.
Capillary length 5 m.

FEV sensors are installed in rooms where only control of the heating circuit is needed.

The FEV can be used for 2-pipe systems, such as radiators, fan coils, heating panels and induction units.

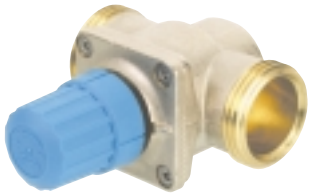
Temperature adjustment range: 17-27°C. It is easy to limit or lock the temperature setting by means of the built-in limiting device.

2.2.4 RA-C
cooling valves

RA-C 15 (013G3094)

A DN15 valve for heating and cooling systems, with a G 3/4 A connection.

RA-C 20 (013G3096)

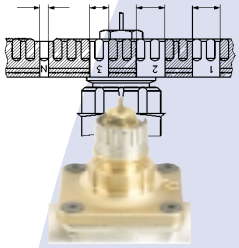


A DN20 valve for heating and cooling systems, with a G 1 A connection.

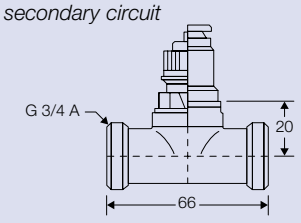
RA-C valves in cooling or heating systems can be combined with Danfoss self-acting climate controllers type FED, FEK, FEV and Danfoss actuators type ABNR, ABNM and AG-EIB.

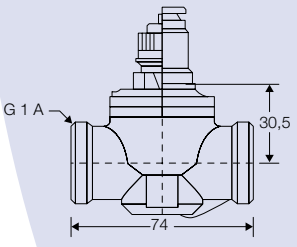
In order to achieve the maximum cooling effect from the terminal unit, a larger amount of water is needed for cooling than for heating systems. This is because the risk of condensation will limit the lowest possible flow temperature. E.g. in chilled ceiling systems, the lowest possible flow temperature is in the range of 14-16°C, which means that a larger amount of water is needed to ensure enough cooling in the room. These large amounts of water could cause noise from the valves. This is why RA-C valves are specially designed to operate at a very low noise level. Moreover, the valves are made of corrosion-resistant brass (DZR), especially designed for chilled water applications.

- *RA-C valves have four pre-settings to ensure correct water flow through the valve*



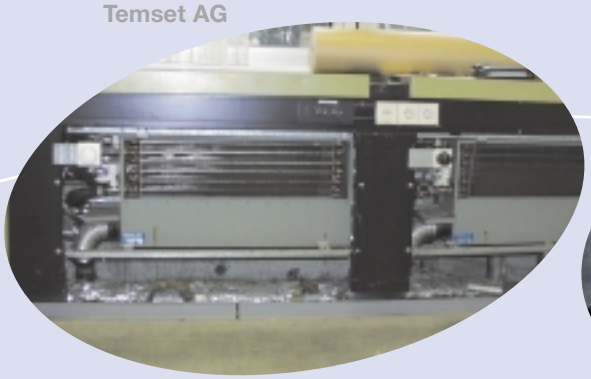
- *External threads - possible to use compression fittings for copper, steel and PEX pipes*
- *RA-C 15: kvs = 1.2 m³/h*
- *RA-C 20: kvs = 3.3 m³/h*
- *PN 16 (maximum static pressure 232 psi)*
- *Maximum Δp 0.6 bar (8.7 psi)*
- *Made of corrosion-resistant brass (DZR)*
- *Max. glycol 40% and closed secondary circuit*





Renovation Project in Karlsruhe, Germany

Building:	Post bank
Room construction:	Office building. Both open offices and cell offices
Danfoss controllers:	FED-FF and RA-C 15/RA-N valves operate both the heating and the cooling circuits
Emitter:	4-pipe heating and cooling installation. Induction units from Temset AG



Renovation Project in Oslo, Norway

Building:	Thiis Gården
Room construction:	Office building. Cell offices – 9 floors with 1,500 m^2 on each floor
Danfoss controllers:	FEK-IF and RA-C 15 valves operate the cooling circuit
Emitter:	2-pipe chilled panels from Nordia
Heating installations:	2-pipe radiators with handwheels
Other:	Danfoss AVDO is used in the end of each string to secure a minimum flow in the string – 8-10 panels pr. AVDO

3. Application overview

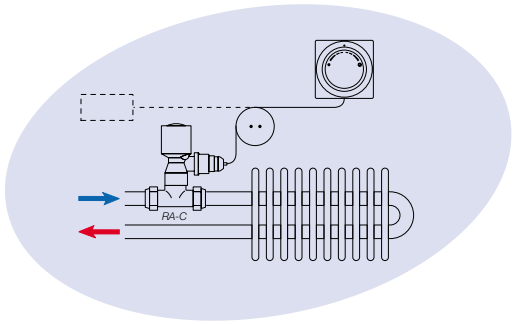
This chapter illustrates how Danfoss self-acting controllers are used:

1. In various piping systems
2. With chilled beams and panels
3. With induction units and fan coils

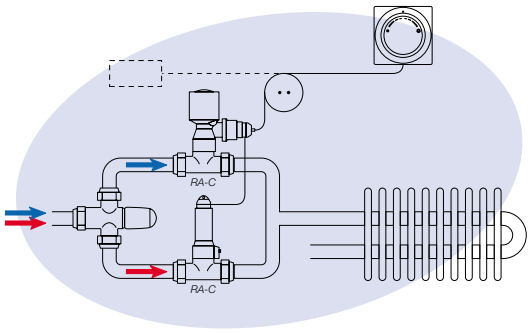
Complete system solutions involving other Danfoss products will also be presented.

3.1 Piping systems

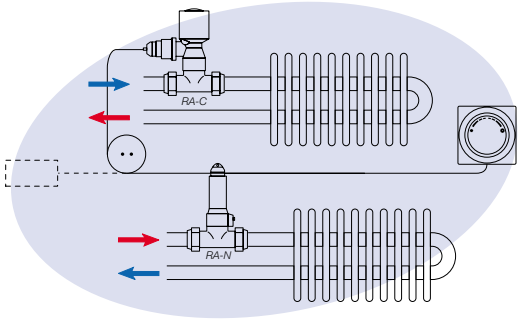
There are many ways of arranging the pipe installations in a comfort cooling system. The sketches illustrate how Danfoss self-acting climate controllers can be mounted on these piping systems.



2-pipe cooling system FEK-FF/FEK-IF.



2-pipe central changeover system FED-FF/FED-IF with 3-way diverting valve.



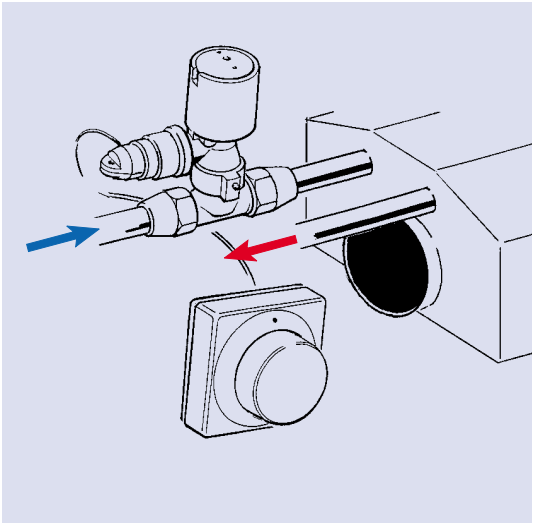
4-pipe heating/cooling system FED-FF/FED-IF.

4-pipe system terminal unit with integrated FED-IF controller.

3.2 Controllers for chilled beams and panels

Controllers for beams and panels
2-pipe systems

FEK-IF: A controller that will only regulate the cooling circuit.



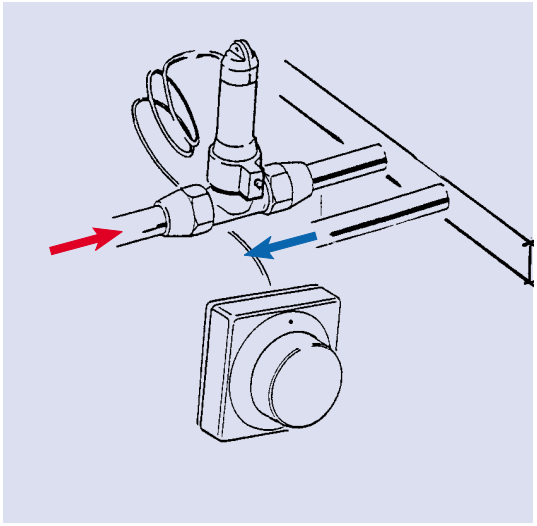
FEK-IF controller with integrated remote setting sensor. The valve type used is the RA-C for chilled water.

Function:
The controller keeps the room temperature constant and ensures a high level of thermal comfort.

When the room temperature rises above the set point temperature (e.g. 22°C), the FEK adapter opens the cooling valve (RA-C) and supplies the chilled beam or panel with chilled water.

Features:
- Temperature range: 17-27°C (63-80°F)
- Option of limiting or locking the temperature range
- Can be used for 2-pipe systems
- Can be used in new or existing buildings where cooling systems are needed
- To be used with the RA-C cooling valve

FEV-IF: A controller that will only regulate the heating circuit.



FEV-IF controller with integrated remote setting sensor. The valve type used is RA-N/FN or RA-C for hot water.

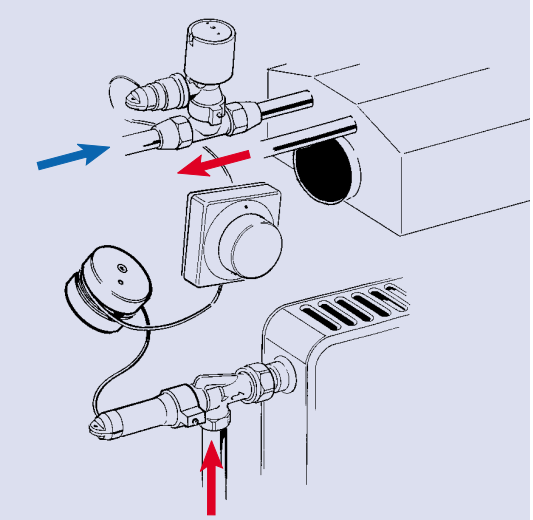
Function:
The controller keeps the room temperature constant and ensures a high level of thermal comfort.

When the room temperature falls below the set point temperature, (e.g. 22°C) the FEV adapter opens the heating valve (RA-N/FN/C) and supplies the chilled beam or panel with hot water.

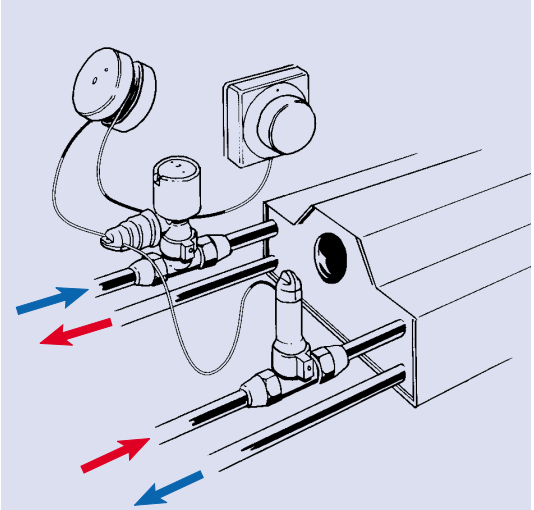
Features:
- Temperature range: 17-27°C (63-80°F)
- Option of limiting or locking the temperature range
- Can be used for 2-pipe systems
- Can be used in new or existing buildings where heating systems are installed
- To be used with the RA-N/FN or RA-C valve

Controllers for beams and panels
4-pipe systems

FED-IF: A controller for chilled ceilings and radiators that regulates both the heating and the cooling circuit.



FED-IF: A controller for 4-pipe chilled beams.



The FED-IF sequential controller operates both the heating and cooling circuit and is with integrated remote setting sensor.
Valve types RA-C or RA-N/RA-FN can be used for hot water, and the RA-C valve can be used for chilled water.

Function:
The controller keeps the room temperature constant and ensures a high level of thermal comfort.
The FED controller regulates both the cooling and the heating valve. The FED controller is equipped with a reverse device for controlling the cooling circuit.
The valve in the heating circuit opens when the temperature falls below the set point temperature (e.g. 22°C).
The heating valve closes if the temperature rises above the set point (e.g. 22°C), and the valve in the cooling circuit opens if the temperature rises above the neutral zone. (e.g. 22°C + neutral zone 1°C).

Features:
- Temperature range: 17-27°C (63-80°F)
- Can be used with various 4-pipe systems or 2-pipe changeover systems
- To be used with the high capacity RA-C valve and the RA-N/RA-FN valve
- Can be used in new or existing buildings where cooling and heating units are to be controlled by a single controller
- The FED elements are easy for the HVAC specialist to install
- The FED regulator generates energy savings, due to the sequential feature; it ensures that cooling and heating do not take place at same time
- It is possible to limit or lock the temperature range
- The FED has a neutral zone that can be adjusted (from 0.5°C - 2.5°C)
- The length of the capillary tube can be adapted to the actual system/terminal unit
- The capillary tube is easy to conceal e.g. if the FED has to be moved
- The FED controller can also be placed directly on the beam

3.2.1 Condensation

When using water-based chilled ceiling systems, there is a risk of condensation.
Chilled panels and beams are not equipped with any kind of drain tray, and damage to the building and furnishings can occur if condensation arises.

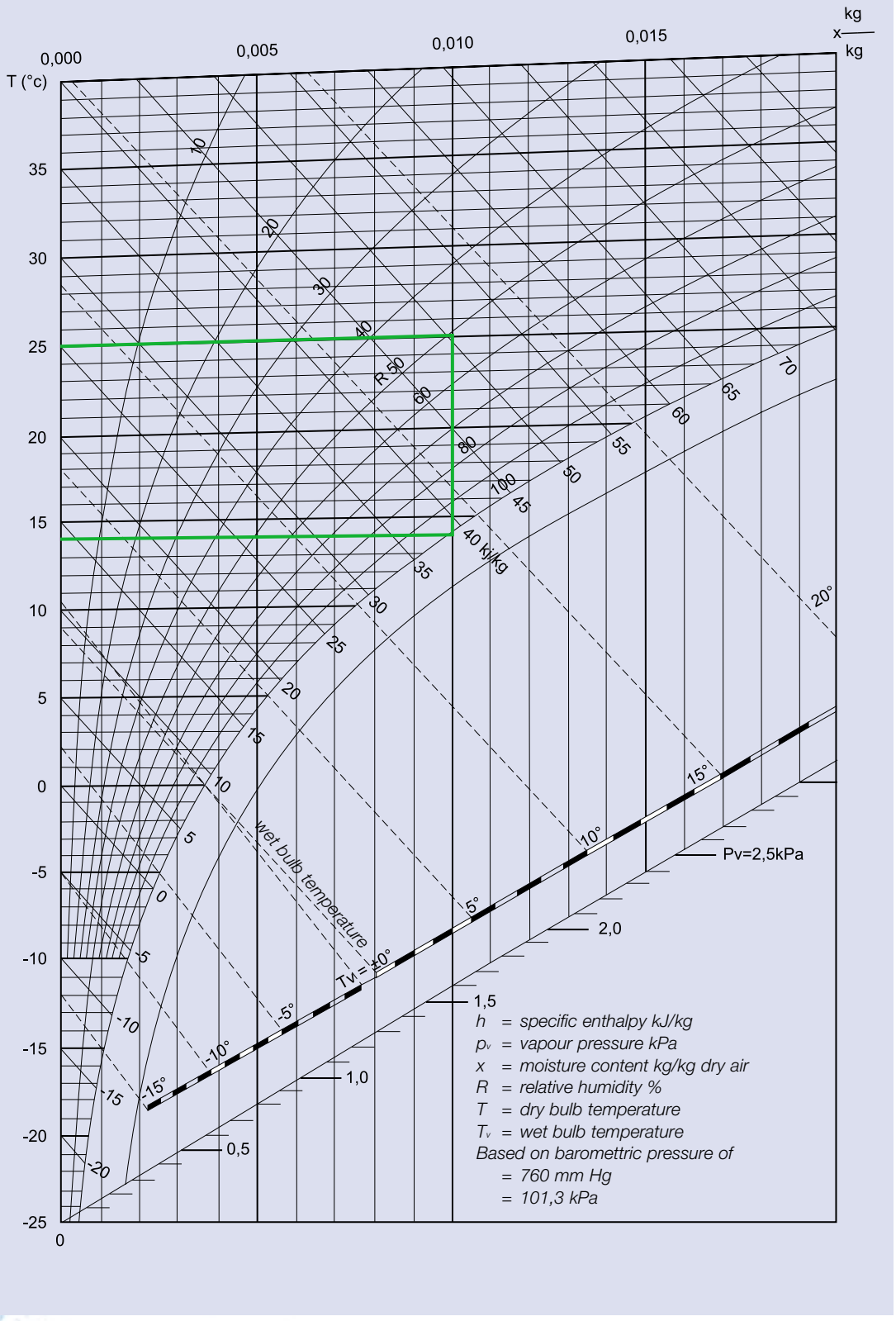
To achieve the maximum cooling effect from the chilled ceiling, the lowest possible flow temperature should be supplied, although low water temperatures can cause condensation. Condensation occurs if the surface temperature of the chilled ceiling is below the dew point of the surrounding air.

Mollier's diagram can be used to calculate how low the flow temperature can be set without causing condensation.

How to determine the dew point temperature: Measure the air temperature and relative humidity, and use the graph.

Example: If the air temperature is e.g. 25°C and the relative humidity is 50%, condensation on the cold surface might occur if the water supply temperature is lower than 14°C.

Mollier psychrometric chart



3.2.2 Dew-point alarm type EDA

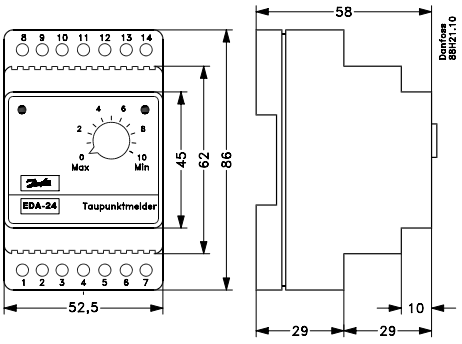
Danfoss dew-point alarm type EDA is an electronic dew-point alarm.

The EDA can be used in connection with Danfoss self-acting climate controllers type FED/FEK (or the Danfoss electronic ECC climate programme).

The electronic dew-point alarm

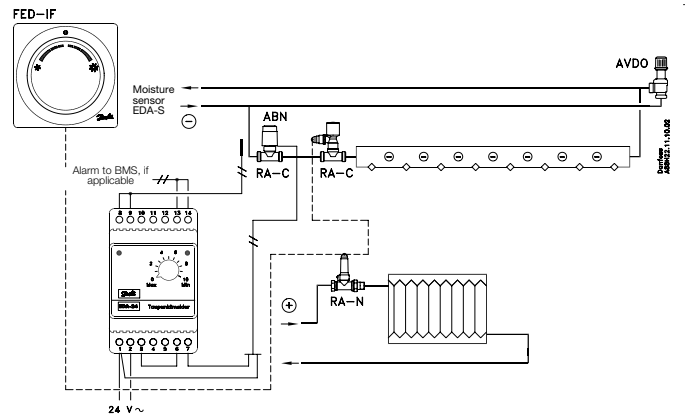
The EDA electronic dew-point alarm is equipped with a sensor type EDA-S that registers if condensate occurs on the flow pipe to the chilled beam or panel.

Dimensions:



Function:
When condensate is registered on the flow pipe by the EDA-S sensor, the EDA electronic dew-point alarm is activated.

In the alarm mode, the two potential-free relays are activated. The relay outputs can be used to shut off the valve and/or to send a signal to an alarm system or BMS/CTS system that condensation is appearing in the zone.



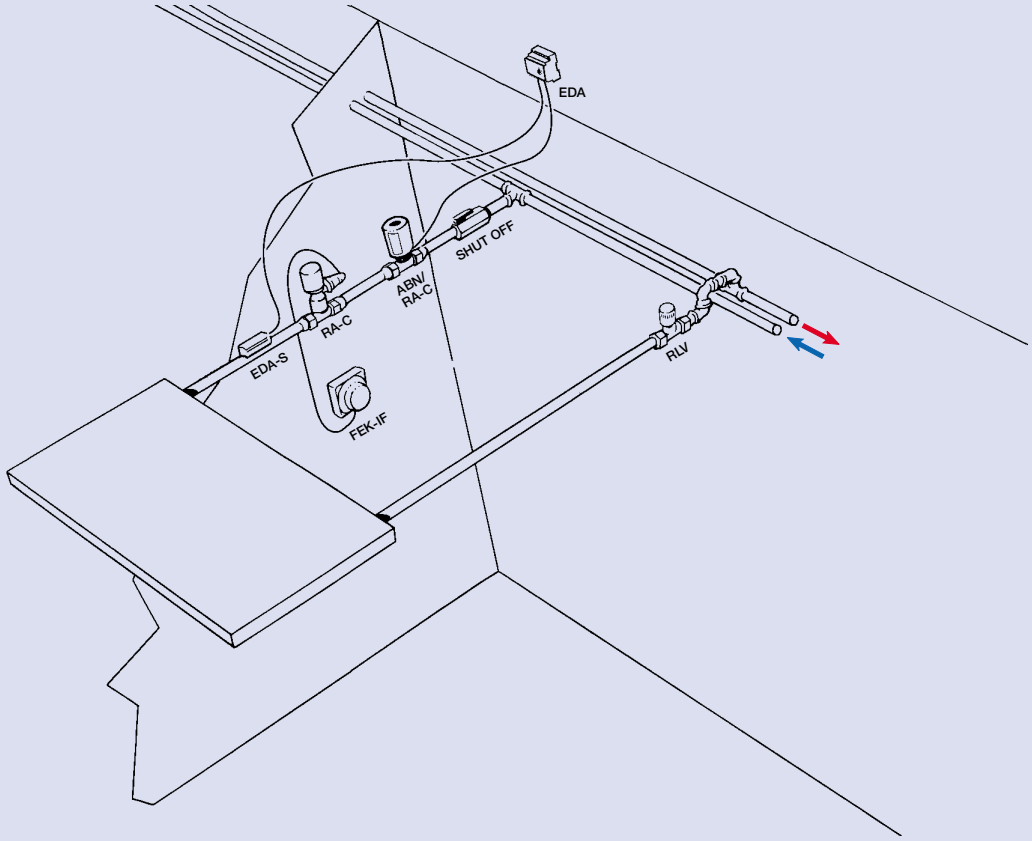
Features:

- EDA has a potentiometer for setting the sensitivity for the EDA-S sensor
- EDA-24 is the electronic dew-point alarm for 24 V supply
- EDA-230 is the electronic dew-point alarm for 230 V supply
- Danfoss type ABN thermal actuators can be used with the EDA dew-point alarm. It is recommended to use NC-version, which also shuts of the valve and thereby the zone in case of failure

3.2.3 System regulation solutions for chilled ceilings

In this section, three types of regulation solutions are presented for comfort cooling systems, when chilled ceilings are used as emitters. These regulation solutions also involve additional Danfoss products for comfort cooling systems.

#1: System regulation solution for chilled ceilings. Cooling system only.



System & advantages:

This is a 2-pipe comfort cooling system where the FEK-IF is mounted on the wall. The FEK-IF will effectively maintain a comfortable room temperature by opening and closing the RA-C valve.

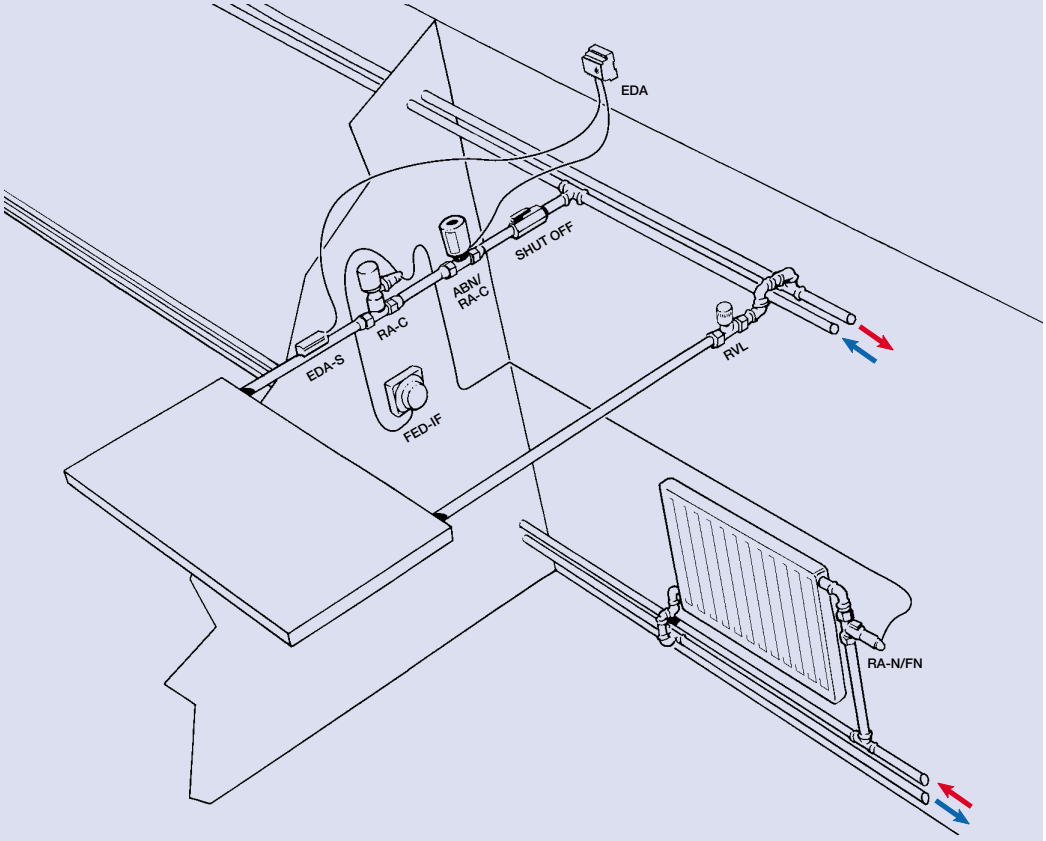
RLV and shut-off valves are installed on both sides of the cooling emitter to ensure that it is easy to close down each chilled ceiling, e.g. for maintenance or cleaning.

With the EDA installed, the system is protected against condensation. EDA-S will detect condensation appearing on the flow pipe and either close the valve or send a signal to an alarm system.

There are two types of RA-C valves – RA-C 15 and RA-C 20 – and they have been specially developed to ensure a low level of noise. To facilitate installation, the RA-C valves are constructed with two external threads to allow them to be easily combined with the existing range of Danfoss compression fittings for plan piping.

This 2-pipe system solution with FEK-IF allows the end-users to set the room temperature locally.

#2: System regulation solution for chilled ceilings. Cooling & heating system.



System & advantages:

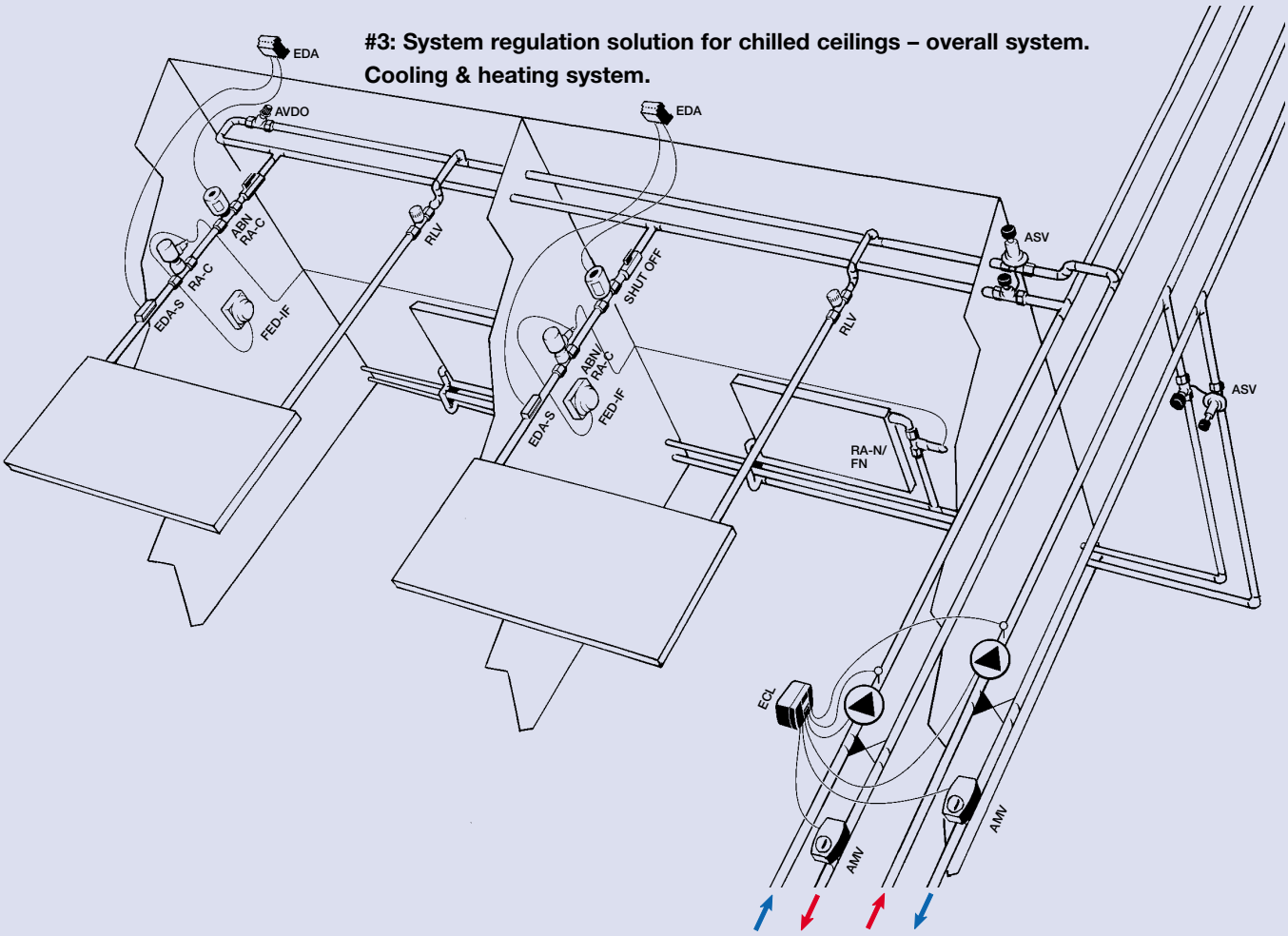
The above illustrates a 4-pipe system solution, where radiators and chilled panels are installed in a room. The FED-IF controller operates both the radiator and the chilled panel sequentially, and ensures that a comfortable room temperature is maintained any time of the year.

The FED has a neutral zone ensuring that the radiator and chilled ceiling are not activated simultaneously – thus avoiding unnecessary heating and cooling expenses.

RLV and shut-off valves are installed to facilitate maintenance of the chilled ceiling. The EDA dew-point alarm protects against condensation on the chilled ceiling.

The FED is particularly advantageous in renovation projects, where heating installations already exist (e.g. with Danfoss thermostats), but new additional cooling systems are to be installed. In this case, the FED heating adapter fits the existing Danfoss valve on the radiator installations and the cooling adapter fits the RA-C value.

#3: System regulation solution for chilled ceilings – overall system. Cooling & heating system.



System & advantages:

This illustration shows a 4-pipe system from an overall perspective. Chilled ceilings and radiators are installed as cooling and heating emitters in each room. The FED is installed to maintain a comfortable room temperature. In addition, the EDA is installed to prevent condensation.

To control the flow temperature for both the heating and cooling circuits, Danfoss ECL controllers are used. Danfoss produces a variety of ECL controllers ensuring energy savings and that the flow water for the radiators and the chilled ceilings has the right temperatures.

Automatic balancing valves, Danfoss ASV valves, for example, ensure a constant differential pressure and a sufficient amount of water for each emitter.

If the strings with chilled water are long, a small bypass in the system can be necessary. The water pipes will be heated if the 2-way valve is closed for a long period of time. This problem is solved by installing a bypass valve, such as a Danfoss AVDO, at the end of the string. The AVDO maintains a minimum flow in the system.

Renovation Project in Västerås, Sweden

Building:	Mälardalens High School
Room construction:	Class rooms and office building. Both open and cell offices
Danfoss controllers:	FEK-IF and RA-C 15 + RA-C 20 valves operate the cooling circuit
Emitter:	2-pipe chilled beams from Fläkt Ventilation AB
Heating installations:	2-pipe radiators with Danfoss thermostats
Other:	In some larger rooms there is a piping solution where one FEK-IF is installed to operate 2 beams. In these cases the RA-C 20 is used (see page 27).

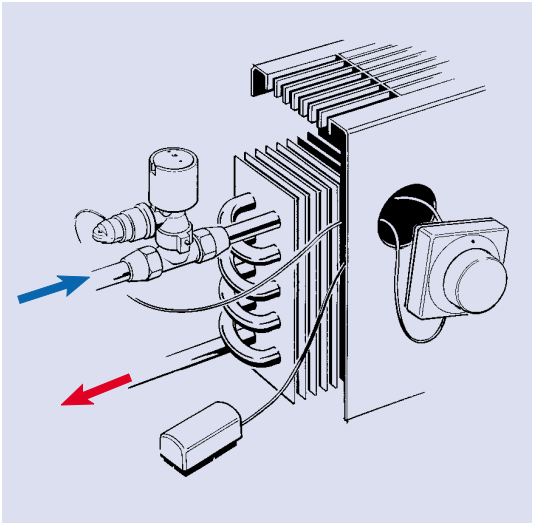
Renovation Project in Halmstad, Sweden

Building:	Halmstad Police Station
Room construction:	Office building. Cell and open offices
Danfoss controllers:	FED-IF and RA-C 15/RA-N valves operate both the heating and the cooling circuits
Emitter:	2-pipe chilled beams from Lindab
Heating installations:	2-pipe radiators

3.3 Controllers for fan coils and induction units

Controllers for fan coils and induction units
2-pipe systems

FEK-FF: A controller that only controls a cooling circuit.



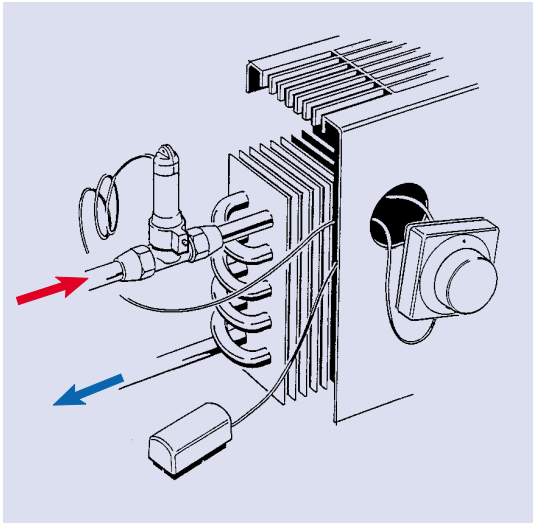
The FEK-FF controller for fan coils and induction units is equipped with a remote setting sensor. The remote sensor can, for example, be placed below the cabinet or in the air inlet to the room.

Function:
The controller keeps the room temperature constant by regulating the valve and the flow of chilled water.

When the room temperature rises above the set point temperature (e.g. 22°C), the FEK sensor will open the cooling valve and supply the fan coil or induction unit with chilled water.

Features:
- Temperature range: 17-27°C (63-80°F)
- The set point temperature is adjustable and is set on the FEK-FF controller
- Used for 2-pipe systems
- The liquid-filled controller regulates the valve via capillary tubes and an adapter
- To be used with RA-C cooling valves

FEV-FF: A controller that only controls a heating circuit.



The FEV-FF controller for fan coils and induction units is equipped with a remote setting sensor. The remote sensor can, for example, be placed below the cabinet or in the air inlet to the room.

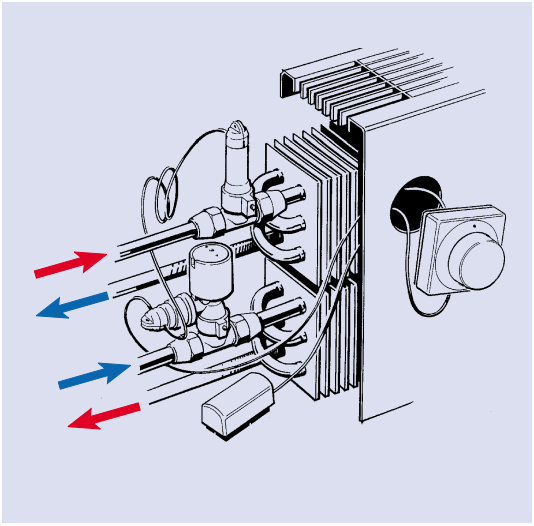
Function:
The controller keeps the room temperature constant by regulating the valve and the flow of hot water.

When the room temperature falls below the set point temperature (e.g. 22°C), the FEV sensor will open the heating valve and supply the fan coil or induction unit with hot water.

Features:
- Temperature range: 17-27°C (63-80°F)
- The set point for the temperature is set on the FEV-FF controller
- Used for 2-pipe systems
- The liquid-filled controller regulates the valve via capillary tubes and an adapter
- To be used with RA-N/FN/C valves

Controller for fan coils and induction units
4-pipe systems

FED-FF: A controller that operates both the heating and the cooling circuit.



The FED-FF sequential controller operates both the heating and cooling circuits and is equipped with a remote setting sensor. The remote sensor can, for example, be placed below the cabinet or in the air inlet to the room.

Valve types: RA-C or RA-N/FN valves for hot water and the RA-C valve for chilled water.

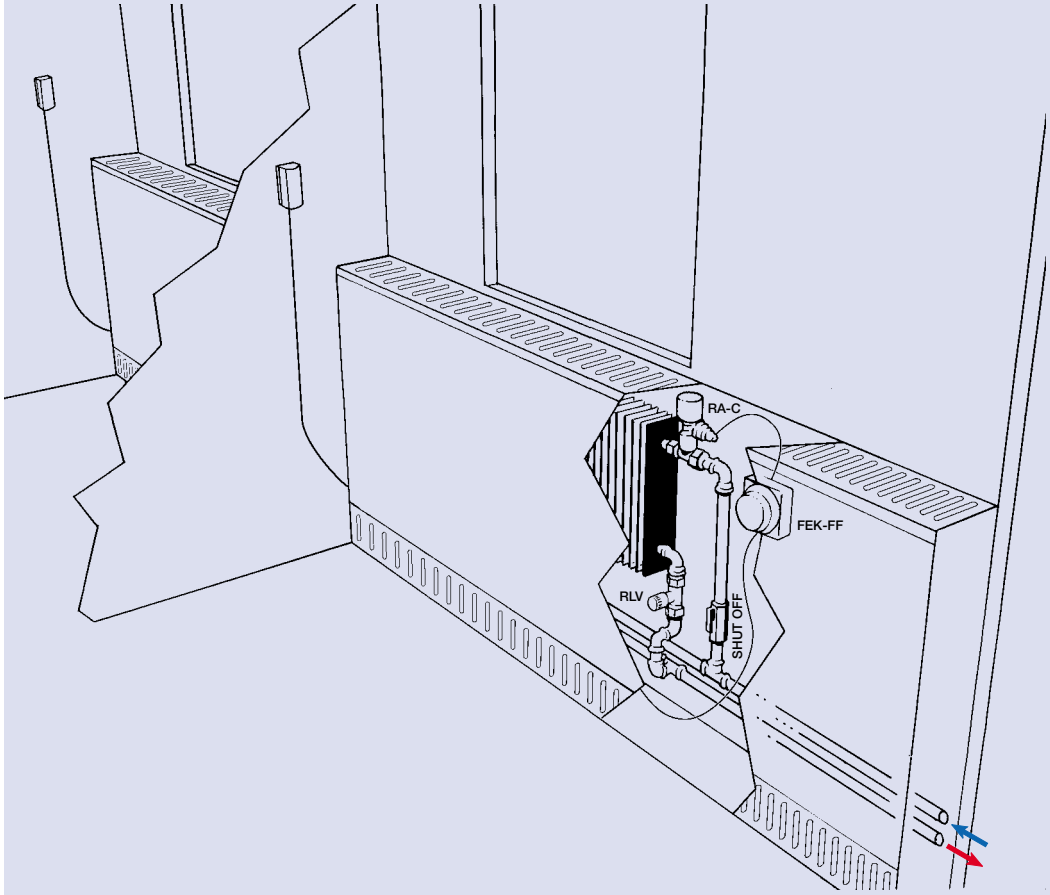
Function:
The controller keeps the room temperature constant and ensures a high level of thermal comfort.
The FED controller regulates both the cooling and the heating valve.
The valve in the heating circuit opens when the temperature falls below the set point temperature (e.g. 22°C).
The heating valve closes if the temperature rises above the set point (e.g. 22°C), and the valve in the cooling circuit opens if the temperature rises above the neutral zone. (e.g. 22°C + neutral zone 1°C).

Features:
- Temperature range: 17-27°C (63-80°F)
- Can be used for various 4-pipe systems
- To be used with the high-capacity RA-C valve and RA-N/FN valves
- Can be used in new or existing buildings where cooling and heating units are to be regulated by a single controller
- The FED is easy for the HVAC specialist to install
- The FED generates energy savings, due to the sequential feature; it ensures that cooling and heating do not take place at same time
- It is possible to limit or lock the temperature range on the FED
- The FED controller has a neutral zone that can be adjusted (from 0.5°C - 2.5°C)
- The length of the capillary tube can be adapted to the actual system/terminal unit
- The capillary tube is easy to conceal, e.g. if the FED has to be moved
- The set point temperature is adjustable and is set on the FED

3.3.1 System regulation solutions for fan coils/induction units

In the following, three types of system regulation solutions are presented for comfort cooling systems in which fan coils or induction units are used as emitters. These regulation solutions also involve additional Danfoss products for comfort cooling systems.

#1: System regulation solution for fan coils/induction units. Cooling system only.



System & advantages:

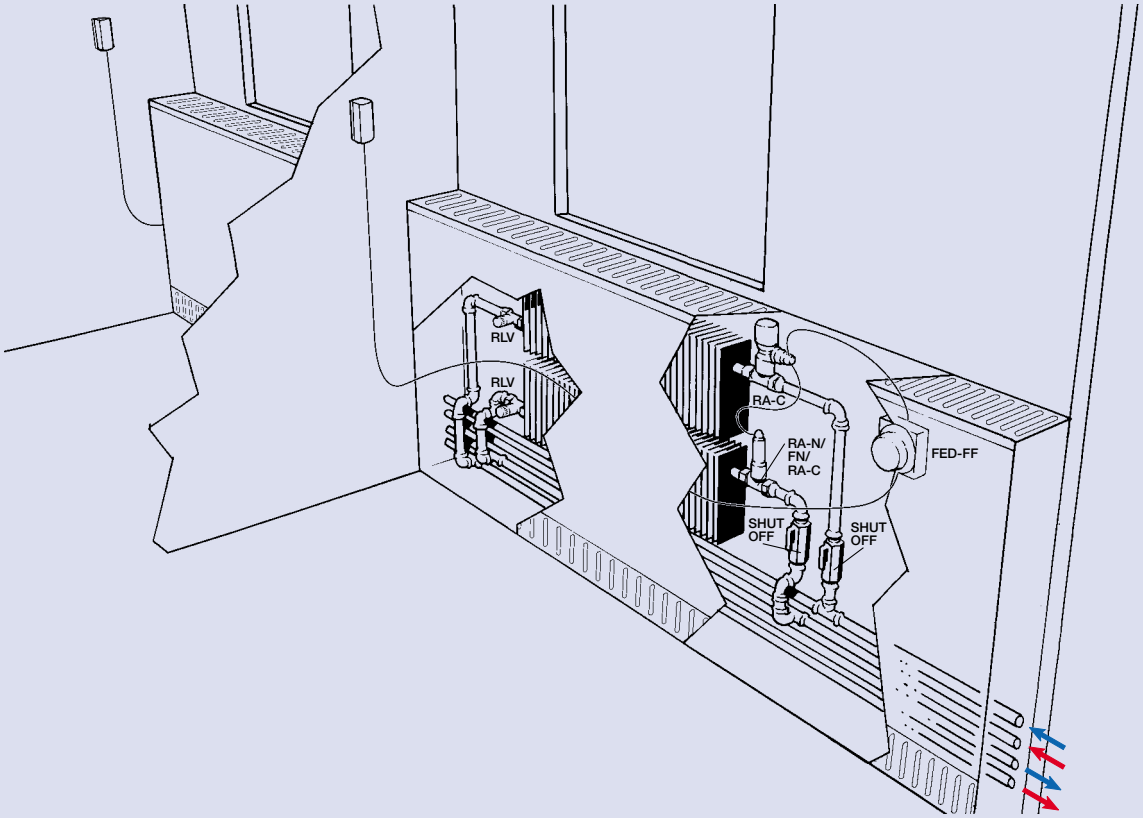
A 2-pipe comfort cooling system in which the FEK-FF is mounted on the fan coil or induction unit. The FEK-FF effectively maintains a comfortable room temperature by opening and closing the RA-C valve.

RLV and shut-off valves are installed to facilitate maintenance of the cooling emitter.

The 2-way RA-C valve is installed on the flow pipe. If constant flow of water is needed, it is suggested that a bypass valve, such as a Danfoss AVDO, is installed on the string.

The AVDO works as a bypass controller. If the pressure in the system increases because the RA-C valve closes, the AVDO bypass valve will open and maintain a minimum flow in the system.

#2: System regulation solution for fan coils/induction units. Heating and cooling system.



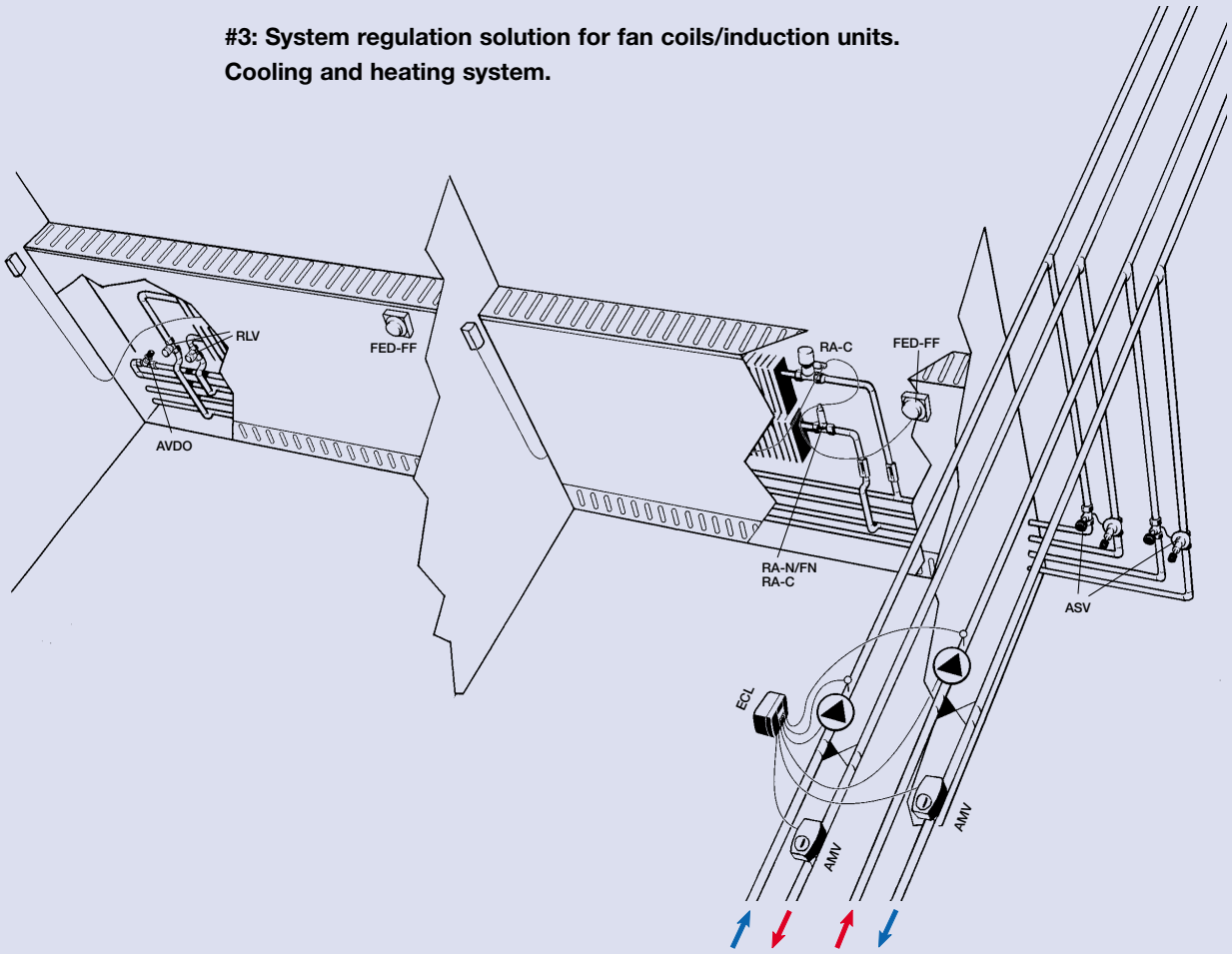
System & advantages:

A 4-pipe cooling and heating system in which the FED-FF is mounted on the fan coil or induction unit. The FED-FF effectively maintains a comfortable room temperature by opening and closing the heating and cooling valves.

The high-capacity 2-way RA-C valve is installed on the flow pipe. If constant flow of water is needed, it is suggested that a bypass valve, such as a Danfoss AVDO, is installed at the end of the string.

The AVDO works as a bypass controller. If the pressure in the system increases because the RA-C valve closes, the AVDO bypass controller will open and maintain a minimum water flow in the system.

#3: System regulation solution for fan coils/induction units. Cooling and heating system.



System & advantages:

This illustration shows an overall system for fan coil or induction units. ECL controllers are used to regulate the flow temperature for the heating and cooling circuits. The ECL controllers ensure that the flow temperature to the heating and cooling circuits is at the right temperature.

The FED regulates the room temperature. It opens and closes the heating and cooling valves, depending on the thermal load.

In large systems with long strings it can be necessary to install a small bypass valve to ensure an instant supply of chilled water to the room when the valve opens. The bypass valve – e.g. a Danfoss AVDO – is placed at the end of the string.

Automatic balancing valves – e.g. ASV differential pressure valves – are installed to ensure an optimally balanced system and to ensure that enough water is supplied to each emitter.

If constant flow is needed in the system to prevent the chiller from freezing, the AVDO can be used on the main string.

3.4 Regulation solutions in open office areas

Danfoss self-acting controllers can also be used in open office areas. The solution when using self-acting controllers in open office areas is to make sure that they do not interfere with each other.

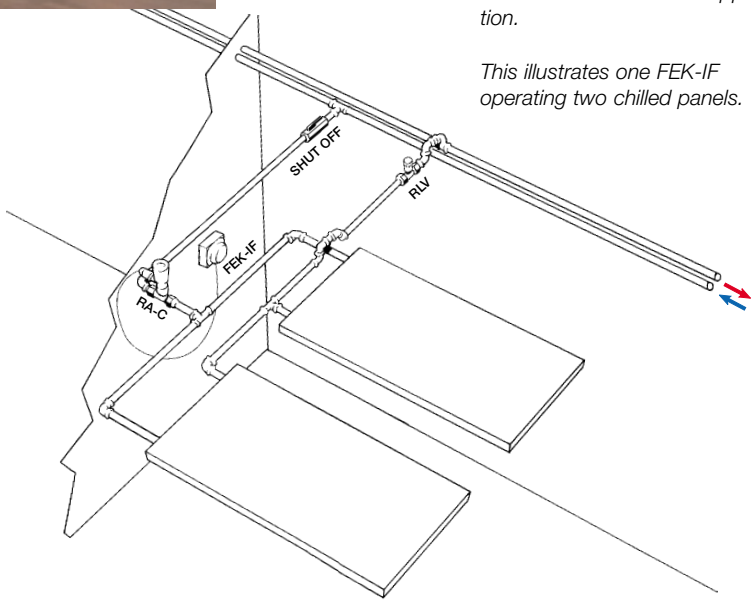
If the set point temperature of all controllers is locked at the same level (e.g. 22°C) there is no problem in placing several self-acting controllers in the same room.

The pictures are from a new construction project where 33 FEK-IF's were placed in the same open office area, and locked at the same set point temperature. The heating installation consists of radiators with thermostats.

The end users (on the other floors in the building which are now rented out) expressed great satisfaction with this regulation solution.

In modestly-sized rooms, it is possible to use a parallel piping solution as shown in the application.

This illustrates one FEK-IF operating two chilled panels.



4. Characteristics of comfort cooling systems

4.1 The use of 2-way valves versus 3-way valves

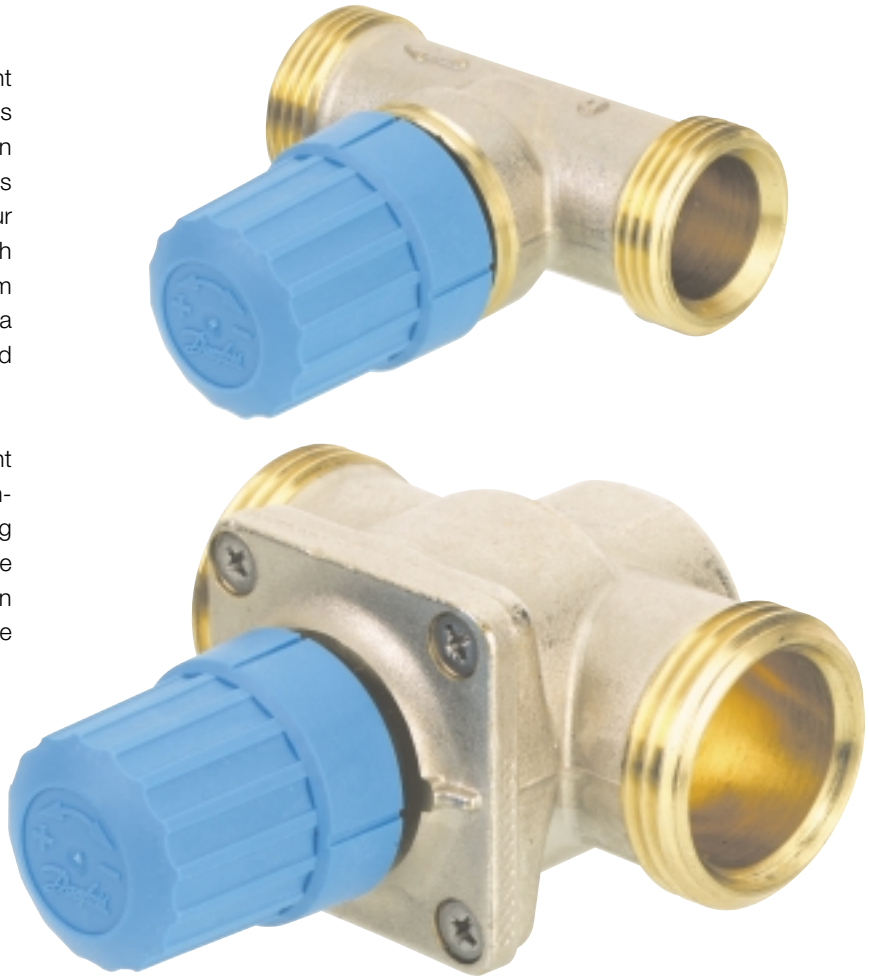
In large hydronic comfort cooling systems, Danfoss recommends the use of 2-way valves and variable flow of water instead of 3-way bypass valves. The reasons for this are as follows:

- Using 2-way valves (and variable flow) is more energy efficient because it is not necessary to constantly circulate the water through the entire system. With badly insulated pipes there is a risk of significant energy loss when a constant flow is maintained.

- With constant flow, a pump is needed to run at a constant speed. Pump operation costs in larger cooling systems are significant, and large energy savings can be generated by using variable flow.

- Experience from heating systems has taught us that it is often hard to balance the systems with 3-way bypass valves. In addition, this can cause noise problems. These problems associated with 3-way valves can also occur when used in cooling systems. It is much easier for the installer to balance the system with 2-way valves (with pre-settings), and a superior system can be achieved if balanced with automatic balancing valves.

- To avoid freezing of the chillier with constant flow in the primary circuit, Danfoss recommends using a buffer, and having variable flow at the secondary circuit. In the case of long strings, a 2-way bypass valve can be installed at the end of the string, to secure instant chilled water to the emitter.
(See page 20).



4.2 Balancing comfort cooling systems

There is not much difference in balancing a heating and a cooling system. What is desired in balancing a comfort cooling system is to ensure that a correctly calculated amount of water is distributed to all fan coils, induction units, chilled beams, and chilled panels in the system. Hence the aim is to make sure that the right amount of water is distributed even to the most remote emitter, so that every emitter can provide the calculated cooling effect in the room.

The actual difference between a heating and a cooling system is the delta t – temperature difference between the flow and return pipe. In a cooling system, delta t is most often around 3-5°C, whereas in a heating system it is around 20-30°C. This means that in a comfort cooling system a very large amount of water volume needs to be transported, and a larger proportion of energy in moving calories around is used.

Therefore, it is important to create accurate and optimal balancing in the comfort cooling system, as the balancing valves cause a trimming of the cooling pumps and ensure that they run at the right number of revolutions. Control valves on fan coils, induction units, and chilled ceilings have good working conditions with low differential pressure, and the valves control and reduce noise to a minimum. Last but not least, the systems create comfort and provide cooling to everyone with as negative impact to the surroundings as technically possible.

4.2.1 Automatic balancing valves – ASV

Danfoss ASV automatic balancing valves provide control valves with the best possible working conditions. This minimises the risk of noise problems and the cost of commissioning.

The ASV series consist of the ASV-PV automatic balancing valve and the ASV-I combined adjustment and shut-off valve. The difference between the balancing valves is primarily that the ASV-PV valve ensures a constant differential pressure between 5 and 25 kPa. (adjustable), factory setting 10 kPa., whereas the, ASV-I, combined adjustment and shut-off valve maintains the maximum flow. The ASV-I is also fitted with nipples for measuring the flow.

The valves have a pressure-relieved cone, which makes them independent of pump pressure.

The ASV-PV/I ensures optimum functioning and balance across the entire riser and is adapted to the normal basis for dimensioning of cooling and heating systems. Therefore, the ASV can most often be selected according to pipe dimensions.

5. Danfoss products for comfort cooling systems

Danfoss provides a wide range of products for comfort cooling systems. This comprises valves, actuators, self-acting controllers and electronic controllers. The product portfolio is presented below.

For further information about these products and/or datasheets, please contact your local Danfoss sales company.

Self-acting controls	Type	Code no.	Sensor	Capillary tube	Setting range
For heating and cooling 	FED-FF	013G5462	Remote	2+2+2 m	17-27°C (63-80°F)
	FED-IF	013G5463 013G5461	Integrated Integrated	4+11 m 7+8 m	
For cooling 	FEK-FF	013G5464	Remote	2+2 m	
	FEK-IF	013G5465 013G5468	Integrated Integrated	5 m 8 m	
For heating 	FEV-FF	013G5466	Remote	2+2 m	
	FEV-IF	013G5467	Integrated	5 m	

Valves

	Type	Code no.	Valve size	Valve connection	Cv (m^3/h)	Designation
	RA-C 15	013G3094	DN15	G 3/4 A	1.2	Valves for cooling and heating
	RA-C 20	013G3096	DN20	G 1 A	3.3	
	RA 2000	013G0013	DN15	Rp 1/2	0.9	Valve for heating
	ASV-PV	003L8016 003L8017 003L8018	DN15 DN20 DN25	G 3/4 A G 1 A G 1 1/4 A	1.6 2.5 4.0	Constant differential pressure valve Adjustment range: 0.05-0.25 bar
	ASV-P	003L8036 003L8037 003L8038	DN15 DN20 DN25	G 3/4 A G 1 A G 1 1/4 A	1.6 2.5 4.0	Balancing valve, with shut-off valve and drain cock Fixed 0.1 bar
	ASV-I	003L8056 003L8057 003L8058	DN15 DN20 DN25	G 3/4 A G 1 A G 1 1/4 A	1.6 2.5 4.0	Combined adjustment and shut-off valve
	ASV-M	003L8096 003L8097 003L8098	DN15 DN20 DN25	G 3/4 A G 1 A G 1 1/4 A	1.6 2.5 4.0	Shut-off valve
	ASV-Q	003L2102 003L2104 003L2106	DN15 DN20 DN25	G 3/4 A G 1 A G 1 1/4 A	1.9 2.9 3.9	Automatic flow limiter
	AVDO	003L6020 003L6025 003L6030	DN15 DN20 DN25	G 3/4 A G 1 A G 1 1/4 A	– – –	Differential pressure controller Adjustment range: 0.05-0.5 bar
	RLV	003L0144 003L0146	DN 15 DN 20	Rp 1/2 Rp 3/4	2.5 3.0	Lockshield valve, "straight"
	KOVM	013U3014 013U3015 013U3020	DN15 DN15 DN15	Rp 1/2 Rp 1/2 Rp 1/2	0.63 1.5 2.0	3-way valve

Actuators

	Type	Code no.	Supply voltage	Designation
Thermal actuator, on/off 	ABNR-NC	082F1023 082F1043	230 V ~ 24 V -/~	Fits RA 2000 valve
	ABNR-NO	082F1123 082F1143	230 V ~ 24 V -/~	
	ABNC-NC	082F1046	24 V	Used for ECC 12 and ECC 22 Fit KOVM, RAV and VMT valves
		082F1045	24 V	Used for ECC 12 and ECC 22 Fits RA 2000 valve with adapter
	ABNA-NC	082F1021 082F1041	230 V ~ 24 V -/~	Used for ECC 24 Fits RAVL valve with adapter (082F1203)
	ABNA-NO	082F1121 082F1141	230 V ~ 24 V -/~	
Modulating valve actuators, 0-10 V: 	ABNM	082F1091	24 V ~	0-10 V - output Fits RA 2000 valve + RA-C valves
Thermo actuators with communication: 	AG-EIB	082F1030	Via bus, 24-29 V	Actuator with EIB communication Fits the RA 2000 valve + RA-C valves

Controllers

	Type	Code no.	Designation	
Programmable room thermostats, HC75:  (Powered by 2 x AA Alkaline batteries)	HC75	087N6685 087N6690	Built-in sensor Remote sensor	Heat/cool thermostat, no fan output
	HC75-1	087N6686 087N6688	Built-in sensor Remote sensor	Heat/cool thermostat, Single-speed fan output
	HC75-3	087N6687 087N6691	Built-in sensor Remote sensor	Heat/cool thermostat, 3-speed fan output (manual)

Controllers

Type	Code no.	Designation	
Programmable thermostats, 6000 series: *For cooling or heating*  (All models are 1 heat or 1 cool. All models available with remote sensors versions)	HCS6100 HCS6101 HCS6103	087N7050 087N7068 087N7054	Battery 24 V ~ 230 V ~	No fan output
	HCS6100-1 HCS6101-1 HCS6103-1	087N7058 087N7072 087N7063	Battery 24 V ~ 230 V ~	Single-speed fan output
	HCS6100-3 HCS6101-3 HCS6103-3	087N7059 087N7073 087N7064	Battery 24 V ~ 230 V ~	3-speed fan output
For cooling or heating, in 2-pipe changeover systems  (With pipe temperature changeover)	HCW6110-1 HCW6111-1 HCW6113-1	087N7052 087N7070 087N7065	Battery 24 V ~ 230 V ~	Single-speed fan output
	HCW6110-3 HCW6111-3 HCW6113-3	087N7061 087N7075 087N7066	Battery 24 V ~ 230 V ~	3-speed fan output
For cooling and heating, in 4-pipe systems (auto changeover) 	HC6110-1 HC6111-1 HC6113-1	087N7062 087N7076 087N7067	Battery 24 V ~ 230 V ~	Single-speed fan output
	HC6110-3 HC6111-3 HC6113-3	087N7053 087N7071 087N7057	Battery 24 V ~ 230 V ~	3-speed fan output
Programmable thermostats, 8000 series: 	HC8110-1 HC8111-1 HC8113-1	087N6803 087N6807 087N6818	Battery 24 V ~ 230 V ~	1 heat, 1 cool, single-speed fan
	HC8110-3 HC8111-3 HC8113-3	087N6905 087N6906 087N6907	Battery 24 V ~ 230 V ~	1 heat, 1 cool, 3-speed fan
	HC8220-1 HC8221-1 HC8223-1	087N6804 087N6808 087N6819	Battery 24 V ~ 230 V ~	2 heat, 2 cool, single-speed fan
	HC8220-3 HC8221-3 HC8223-3	087N6908 087N6909 087N6910	Battery 24 V ~ 230 V ~	2 heat, 2 cool, 3-speed fan

Controllers

	Type	Code no.	Designation	
Non-Programmable thermostats: 	RET B	087N7251	Battery	Cool thermostat, with small LCD, no switch
	RET B-LS	087N7255	Battery	Cool thermostat, with small LCD, Auto/Off switch
	RET B-NSB	087N7259	Battery	Cool thermostat, with small LCD, Day/Night switch
For 2-pipe changeover systems 	RET-C01	087N6790 087N7021	24 V ~ 230 V ~	Heat/Cool switch Single-speed fan switch
	RET-C02	087N6791 087N7022	24 V ~ 230 V ~	Heat/Cool switch Single-speed fan switch
	RET-C03	087N6792 087N7032	24 V ~ 230 V ~	Heat/Off/Cool switch 3-speed fan switch
	RET-C04	087N6793 087N7034	24 V ~ 230 V ~	As RET-C03, labelled with text rather than to symbols
For non changeover systems 	RET-C3	087N6794 087N7023	24 V ~ 230 V ~	Cool thermostat 3-speed fan switch
	RET-C32	087N6795 087N7027	24 V ~ 230 V ~	Cool thermostat 3-speed fan switch
	RET-LS	087N6797 087N7007	24 V ~ 230 V ~	Heat or cool thermostat No fan output
	RET-LS2	087N6888 087N7009	24 V ~ 230 V ~	As RET-LS, but includes a volt-free switch
ECC electronic controllers 	ECC12	087B0061	24 V ~	2 heating or 2 cooling circuits
	ECC22	087B0062	24 V ~	2 heating and 2 cooling circuits, sequential
	ECC24	087B0072	24 V ~	Sequential 4-pipe heating and cooling (on/off)
	ECC-R	087N0050 087N0051 087N0052	10-30°C ± 5°C 12.5-27.5°C ± 2.5°C Tamper-proof version	Room control panel for ECC12, ECC22, ECC24

Controllers

Type	Code no.	Designation	
Other electronic climate products 			
EDA-24	088H3001	24 V ~	Electronic dew-point alarm
EDA-230	088H3002	230 V~	
Controllers for main supply system 			
ECL 200	087B1120	230 V~	Universal controller for 1 circuit To be used with card P16 or P30
	087B1124	24 V ~	
ECL 300	087B1130	230 V~	Universal controller for 2 circuits To be used with card C62
	087B1134	24 V ~	
Programmable cards for ECL controllers: 			
Card P16	087B4660 1)	Constant temperature control (PI) For ELC200	
Card P30	087B4664 1)	Weather compensation (PI) For ECL200	
Card C62	087B4808 1)	With 2 flow and 2 return temperature sensors (PI) For ECL300	

1): User instructions in English. Code number is language dependent. For languages other than English, contact your Danfoss sales company.

Temperature sensors

Type	Code no.	Designation	
			
ESM-11	087B1165	Pt 1000 flow temperature sensor (surface type) For ECL controller	
ESM-10	087B1164	Pt 1000 outdoor sensor For ECL controller	
			
ESMU	084N1050	100 mm	Pt 1000 immersion sensor Stainless steel, for ECL controller
	084N1051	250 mm	
	084N1052	100 mm	Pt 1000 immersion sensor, Copper, for ECL controller
	084N1053	250 mm	
			
ECC-S	087N0055	Supply air temperature sensor NTC 12000 Ω, for ECC-12 and ECC-24	
			
EDA-S	088H3011	Sensor for electronic dew-point alarm, for EDA-24 and EDA-230	
			
TS2	087N6811	Remote room sensor, for the HC8000 series	
TS5	087N6812	Remote duct sensor, for the HC8000 series	
TS6	087N6813	Outdoor sensor, for the HC8000 series	

5 reasons why Danfoss self-acting climate controllers are an attractive alternative to electronic controllers:

Flexibility

Some new constructions are built before the office space is rented out and, therefore, the landscape or office solution has not been decided upon when the emitters are installed. In this case a self-acting climate controller provides an optimum solution. The self-acting controller can be mounted directly on the emitter (e.g. on a beam). If you change the office landscape, it is a simple matter to change the location of each controller. The capillary tubes are flexible in length and can easily be concealed.

In renovation projects (with an existing heating circuit) where a new cooling circuit is to be installed the new self-acting controller is easy to install. The FED can operate both the old radiator installation and the new cooling installation with one controller.

End-user friendly

Every end-user will know how to operate a self-acting climate controller because they are most likely to have a self-acting controller in their own home. It is usually easier to get individual thermal comfort with self-acting controllers. This is because electronic controllers are often set to regulate a number of offices or an entire zone whereas each self-acting controller regulates just one or a pair of heating and cooling units.

Reliability

The operating life of all self-acting Danfoss controllers is often more than 20 years, and during their lifetime they need no upgrading and little maintenance. The self-acting controllers use the same mechanical principle as the 300 million Danfoss radiator thermostats that are currently used worldwide to ensure optimum room temperature and comfort.

Cost benefit

Self-acting technology gives considerably lower purchase, installation, operation and maintenance costs compared to electronic solutions. For one thing, electricity is NOT required when installing self-acting controllers. Mains connections are thus unnecessary, as is the need for electricians, transformers, special approvals, etc.

Quality

Danfoss has produced self-acting controller solutions for more than 50 years. We transform our experience into premium valves and controllers that undergo a strict quality check before they leave the factory. In addition, Danfoss is certified according to the ISO 14001 and 9001 standards.