ENGINEERING TOMORROW

Optimal 1 Tool

Renovation of one-pipe system in an easier way

The cost of changing to a two-pipe system is a few times higher than the renovation of a one-pipe system

hbc.danfoss.com

Introduction

The Optimal 1 tool is based on a combination of three Danfoss products with accessories: automatic balancing valves (AB-QM) with QT sensor and thermostatic radiator valves (RA-G), used for renovation of residential one-pipe heating systems.

Why use Optimal 1 tool?

- To optimize operational cost through energy savings.
- To optimize heating systems by means of improved heat distribution.
- To improve indoor comfort.

Energy savings of up to 20-30% by installing thermostatic radiator valves + dynamic balancing valves can be achieved with an average payback time of less than three years!

The Optimal 1 tool is developed to give a guideline for renovation of existing one-pipe heating systems. Hydronic balance can be improved without detailed calculations. The tool will help to:

- Correct the flow and reduce the risk of different disturbances (like back flow)
- Make thermostats fully functional
- Improve installation conditions (Built-in sensors, remote sensors, etc…)
- Correct system temperatures in supply and return
- Optimize pump head (with one measurement only!)
- Make it possible to provide fair payment for heating with heat cost allocation (HCA)

With the right balance in the system, correct flow and temperature in the system are obtained.

RADIATOR THERMOSTAT WITH GAS FILL
Recommended to use in multifamily houses without accounting.

HIGH-CAPACITY RADIATOR VALVE
Without presetting. Designed for one-pipe heating systems.

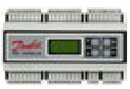
RTD-CB
Prevents radiator back-flow and heat transfer at the return pipe in a one-pipe system in case of closed radiator valve.

RTD-BR
Decreases flow through the bypass in a one-pipe system, thus forcing the correct amount of system water to pass through the radiator.

AB-QM AUTOMATIC BALANCING VALVE WITH PERCENTAGE SETTING SCALE
Designed to keep constant flow.

QT SELF-ACTING THERMOSTATIC ELEMENT
It is set manually. Designed to keep return flow temperature in the riser.

CCR3 CONTROLER
Designed to regulate return risers' temperatures according to the flow temperature from heating sub station/boiler station.



ESMC SURFACE SENSOR AND AB-QM WITH TWA-Z THERMAL ACTUATOR
Designed to measure return riser temperature and to close balancing valve.

Optimal 1

Optimal 1 is a tool that enables you to get control of your radiators and automatic balancing valves in a one-pipe heating system. With this tool you will – in a very easy way– be able to select the right balancing valves and thermostatic radiator valves. You will get the right information to calculate presetting of the balancing valves and the alpha value (radiator share of water flow) needed to make the right pressure drop on the by-pass.

The purpose of commissioning is to get the best possible heat distribution as possible. To achieve this, you need to make sure to have the correct flow distributed to the radiators, and to have the correct pressure drop in the by-pass to ensure proper heat emission on the whole surface of the radiator even at partial load conditions.

It also means that you should validate what kind of radiators are installed in the system, whether the system was changed by tenants or not (for example bigger radiators, other pipes…)

Aluminium radiators are not recommended due to the risk of noise!

A proper difference in temperature between flow and return, also referred to as ΔT, means that the right amount of water goes through the risers and radiators. This improves the efficiency of district heating network or boiler and consequently the indoor temperature meaning comfort level will be high compared to before the renovation.

To locate a possible imbalance in the system and to document improvements of the operating cost in the system at a later stage, it is important to start with documenting the current state and possible issues of the existing system, in cooperation with the facility manager and the residents.
With the outcome of this analysis, the next steps to optimize the heating system -after finishing the installation– can be determined.

Complex renovations including insulation, modern substation and others lead to changes in heat demand and it is necessary to recalculate the existing heating system. Optimal 1 will help you design and commission your system in an easy way.

Step 1:
Analyze the one-pipe heating system

Do the tenants in the building experience any of these problems?

- ☐ noise problems (ticking, whistling, bubbling sounds, etc.)
- ☐ under/overheating / indoor comfort problems
- ☐ long startup times (when it takes a long time before the radiator is heated)
- ☐ unfair billing regardless heat cost allocators (differences between similar apartments)
- ☐ other ....

Building condition description:

What is the year of construction of the building? ....

Was the building modernized in the past years (new windows, Insulation, increased wall thickness)?

....

What is the total energy consumption of the entire building during the last three heating seasons (If possible, without domestic hot water)?

Heating season ....../...... (e.g. 2014/2015) .... ☐ GJ/ ☐ m^3

Heating season ....../...... (e.g. 2015/2016) .... ☐ GJ/ ☐ m^3

Heating season ....../...... (e.g. 2016/2017) .... ☐ GJ/ ☐ m^3

Heating condition description:

What kind of substation (direct or with heat exchanger) or boiler (traditional or condensation) is used?

....

Is weather compensation used, and what is the temperature regime? ....

What kind of circulation pump is used (no control, constant pressure, etc.)? ....

What are pump head settings (kPa/bar)? ....

What type of radiators type is used (Aluminum Noise!)? ....

What are the room temperatures (°C)? ....

Are heat cost allocators installed? ....

What kind of one-pipe system is used (see drawings on page 6-9)?

- ☐ Classical vertical (water flow top-to bottom)
- ☐ T-type (with common supply pipe)
- ☐ T-type (with common return pipe)
- ☐ P-type
- ☐ Other (system without by-pass, etc…)

Any other issues with the heating system that might be relevant (pipe conditions, insulation of pipe, etc.):

....

....

....

What type of radiator valves are installed in the heating system?

- ☐ **A** No radiator valves at all
- ☐ **B** 2-way manual radiator valves
- ☐ **C** 3-way manual radiator valves
- ☐ **D** Thermostatic radiator valves

What type of balancing valves are installed in the heating system?

- ☐ **A** No balancing valves at all
- ☐ **B** Orifices (or similar device)
- ☐ **C** Manual balancing valves
- ☐ **D** Automatic balancing valves (flow limiters)
- ☐ **E** Automatic balancing valves (flow limiters) with self-acting or electronic temperature sensors

Is the system commissioned (if you have answered C, D or E in previous answer)?

- ☐ Yes
- ☐ Yes, but only calculated pre-setting has been done on balancing valves (No pressure or flow verifications)
- ☐ Yes, but no report available
- ☐ Yes, but the balancing valves do not work properly
- ☐ No

Did you tick any of the red square boxes? Then the one-pipe radiator system should be optimized.

Proceed to Step 2.

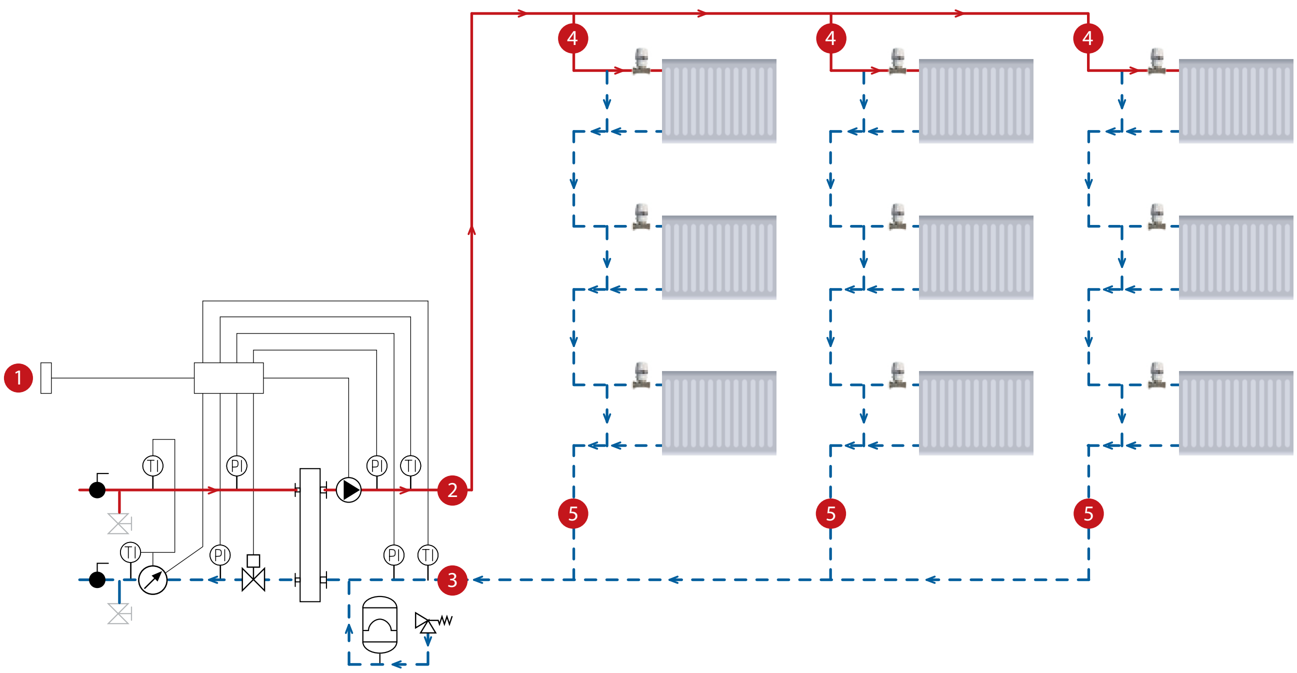
Step 2:
Measure and record Classical system

Please **measure** and record the following temperatures three times during one day (before renovation).
The exact measure points are marked with a number in the drawing below.

- the current outdoor temperature (1)
- the outgoing flow temperature of boiler / heat exchanger (2)
- the outgoing return temperature on boiler / heat exchanger (3)
- the flow temperature on the top of each riser (4)
- the return temperature on the bottom of each riser (5)

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

Fig 1: Measuring points



Time	Outdoor Temp. °C (1)	Flow Temp. °C (2)	Return Temp.°C (3)	Riser Temp. (top) (4)	Riser Temp. (bottom) (5)	Static Pressure	Primary Pressure (P1)	Primary Pressure (P2)
06:00 hr.								
14:00 hr.								
22:00 hr.								

Radiator material?
If possible collect current drawings, settings, calculations?
Any noise problems, where, when (in cold or intermediate) and which apartments?
Any problems with room temperature/comfort where, when and which rooms?
Any noise from substation, defect differential pressure controllers, noisy motorized control valves or heat exchangers, etc…?

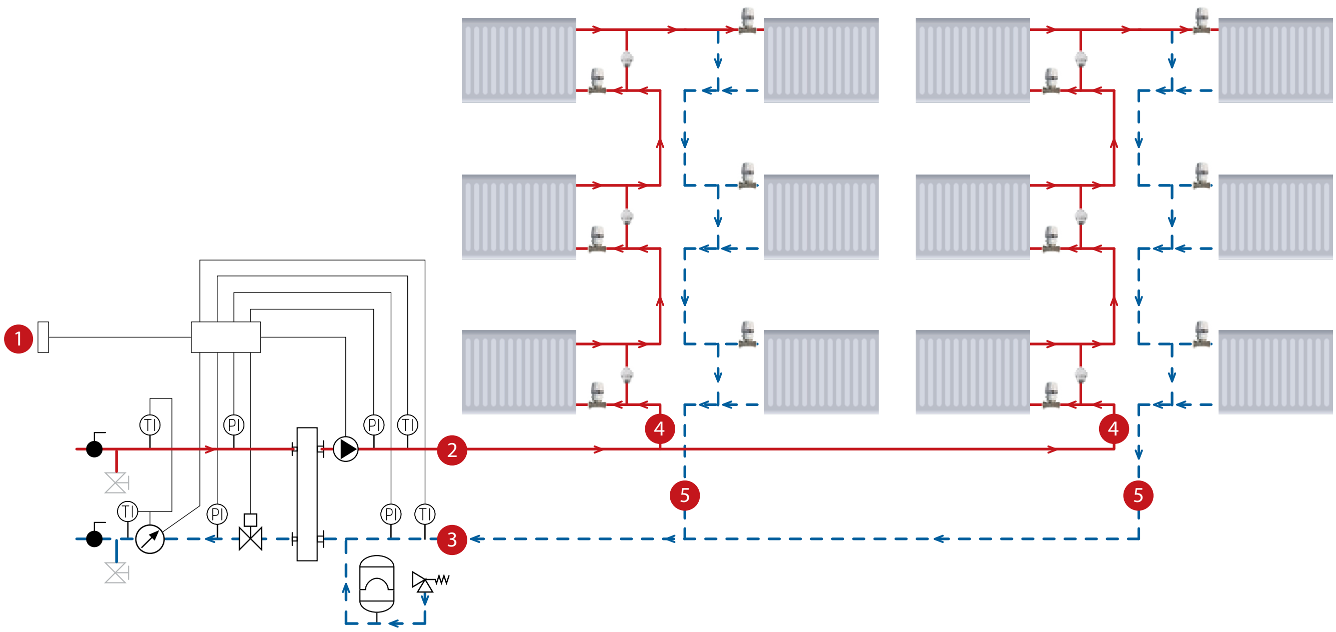
Measure and record P-system

Please **measure** and record the following temperatures three times during one day.
The exact measure points are marked with a number in the drawing below.

- the current outdoor temperature 1
- the outgoing flow temperature of boiler / heat exchanger 2
- the outgoing return temperature on boiler / heat exchanger 3
- the flow temperature on the bottom of each riser 4
- the return temperature on the bottom of each riser 5

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

Fig 2: Measuring points



Time	Outdoor Temp. °C (1)	Flow Temp. °C (2)	Return Temp.°C (3)	Riser Temp. (top) (4)	Riser Temp. (bottom) (5)	Static Pressure	Primary Pressure (P1)	Primary Pressure (P2)
06:00 hr.								
14:00 hr.								
22:00 hr.								

Radiator material?
If possible collect current drawings, settings, calculations?
Any noise problems, where, when (in cold or intermediate) and which apartments?
Any problems with room temperature/comfort where, when and which rooms?
Any noise from substation, defect differential pressure controllers, noisy motorized control valves or heat exchangers, etc…?

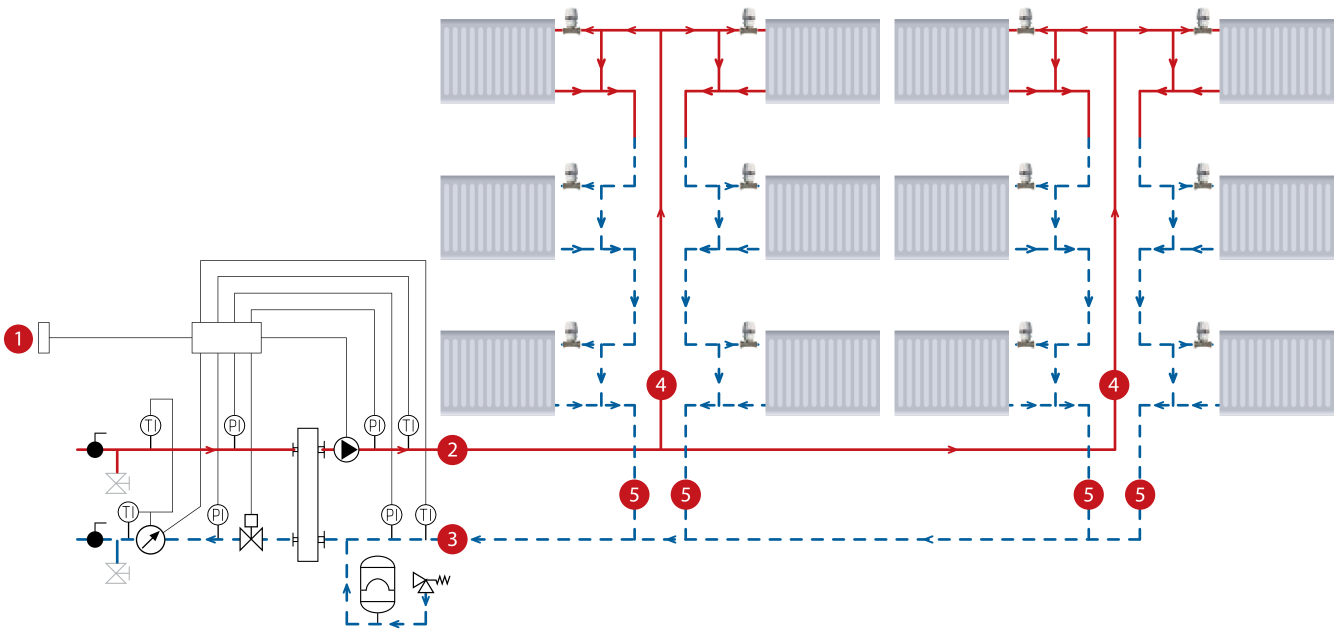
Measure and record T-system ver1

Please **measure** and record the following temperatures three times during one day (if possible).
The exact measure points are marked with a number in the drawing below.

- the current outdoor temperature (1)
- the outgoing flow temperature of boiler / heat exchanger (2)
- the outgoing return temperature on boiler / heat exchanger (3)
- the flow temperature on each riser (4)
- the return temperature on the bottom of each riser (5)

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

Fig 3: Measuring points



Time	Outdoor Temp. °C (1)	Flow Temp. °C (2)	Return Temp.°C (3)	Riser Temp. (top) (4)	Riser Temp. (bottom) (5)	Static Pressure	Primary Pressure (P1)	Primary Pressure (P2)
06:00 hr.								
14:00 hr.								
22:00 hr.								

Radiator material?
If possible collect current drawings, settings, calculations?
Any noise problems, where, when (in cold or intermediate) and which apartments?
Any problems with room temperature/comfort where, when and which rooms?
Any noise from substation, defect differential pressure controllers, noisy motorized control valves or heat exchangers, etc…?

Measure and record T-system ver2

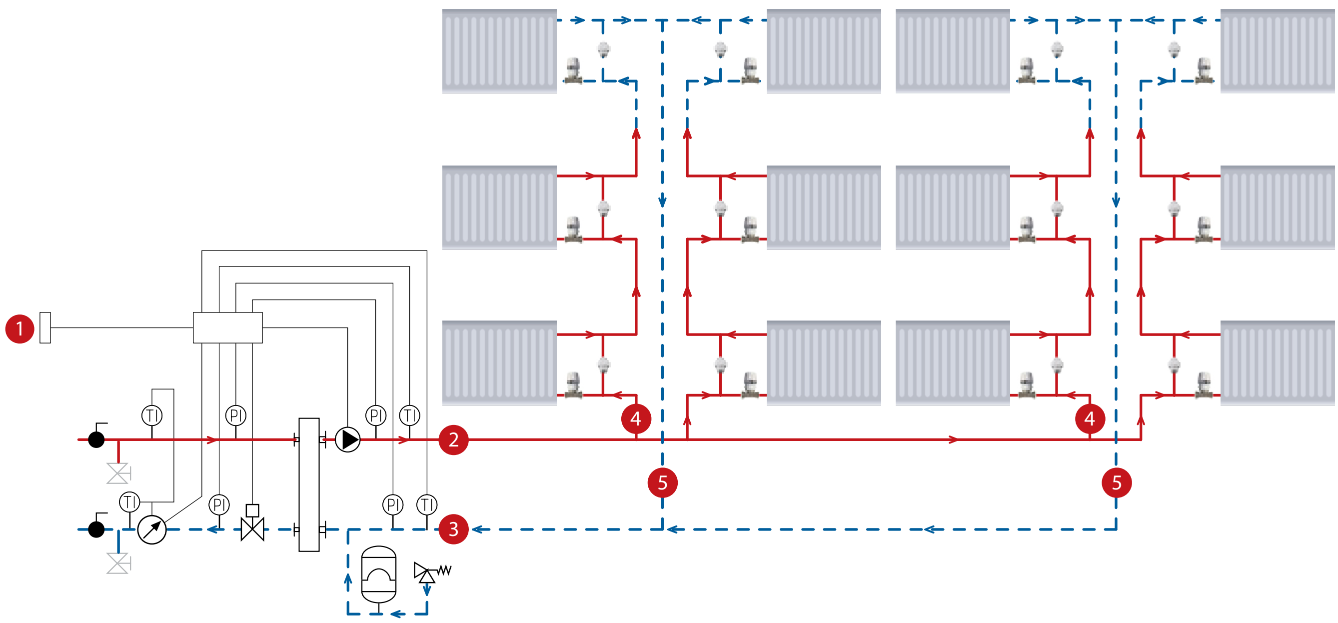
Please **measure** and record the following temperatures three times during one day (if possible).

The exact measure points are marked with a number in the drawing below.

- the current outdoor temperature 1
- the outgoing flow temperature of boiler / heat exchanger 2
- the outgoing return temperature on boiler / heat exchanger 3
- the flow temperature on each riser 4
- the return temperature on the bottom of each riser 5

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

Fig 4: Measuring points



Time	Outdoor Temp. °C (1)	Flow Temp. °C (2)	Return Temp.°C (3)	Riser Temp. (top) (4)	Riser Temp. (bottom) (5)	Static Pressure	Primary Pressure (P1)	Primary Pressure (P2)
06:00 hr.								
14:00 hr.								
22:00 hr.								

Radiator material?
If possible collect current drawings, settings, calculations?
Any noise problems, where, when (in cold or intermediate) and which apartments?
Any problems with room temperature/comfort where, when and which rooms?
Any noise from substation, defect differential pressure controllers, noisy motorized control valves or heat exchangers, etc…?

Step 2a:
Add the measuring results in the graph

Choose a day with as low an outdoor temperature as possible. Measure flow and return temperatures and add value in the graph below, by placing 'dots' at the measured outdoor temperature . Then draw a line to connect the three measured results during the day (see example).

Fig 5: Temperature measurements

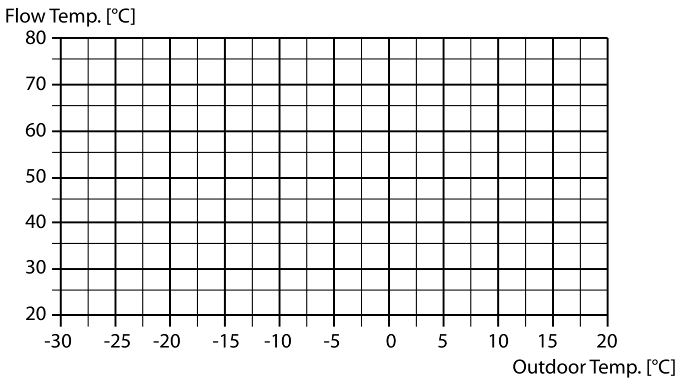
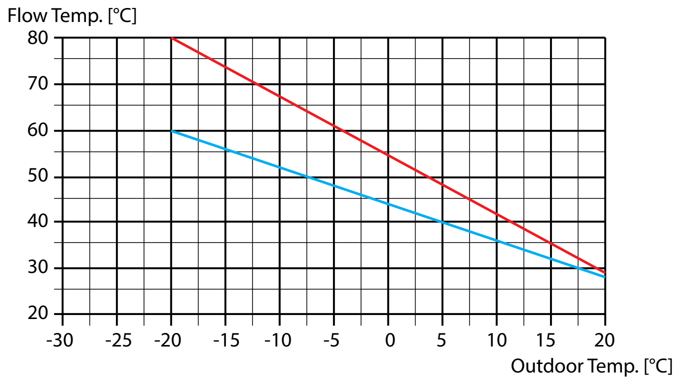


Fig 6: Example



Conclusion

- ☐ if measured temperature difference (ΔT) lower than indicated in table below and you do not have TRV consider system optimization (flow reduction by pump or balancing valves if possible).
- ☐ if measured temperature difference (ΔT) higher than indicated in table below (without usage of TRV) and no claim of under heating (correct radiator size), the system is properly balanced.

Outdoor temperature	ΔT
-20°C	20°C
-15°C	17°C
-10°C	15°C
-5°C	11°C
0°	8°C
5°C	4°C
10°C	2°C

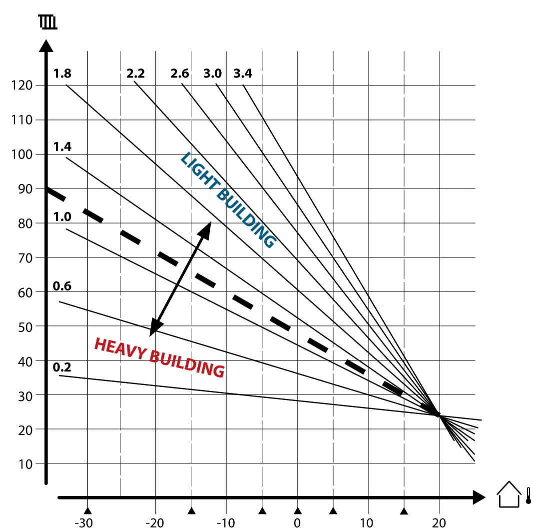
- ☐ In case you have a large temperature drop in distribution lines check the pipe insulation (big temperature drop between point 2 and for on the drawing above).

Note: You can check that the system is not overheated by reducing the flow temperature. If under-heating claim appears the radiators are not oversized.

Step 3:

Open the controller at the heat source (substation/boiler etc…) and read the curve setting. Change and correct (if needed) the heat curve steepness in the controller at the substation according to the optimal heat curve.

The heat curves represent the desired flow temperature at different outdoor temperatures respecting building energy performance. In order to save energy, the flow temperature should be as low as possible, but still considering a comfortable room temperature. Note: Heavy buildings (with high heat accumulation capacity) require lower heat curve slope. Corrections of the heat curve slope should be done in small steps (when having outdoor temperatures below 0 °C; one step pr. Day).

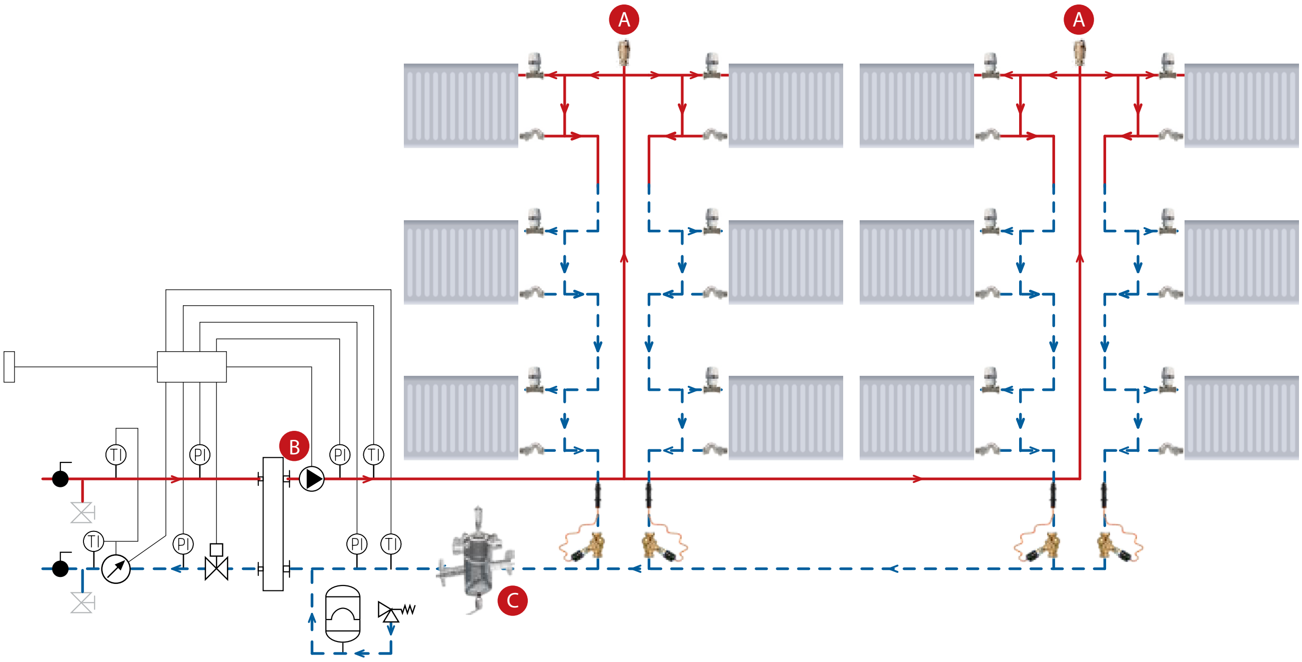


Step 4a:

System protection against air, dirt that can cause noise problems:

- Flush/Clean the risers after instalation
- Fill the system and make sure water is treated to have the right water quality according standard VDI 2035
- Mount automatic air vents on the tallest points of each riser (A)
- De-air the system
- De-air venting with stopped pump (repeat after few days)
- Install pump on supply pipe / remember to use vibration compensators / If old pump is installed recommend to **change to new** (B)
- Mount cyclon dirt and air separator (C)

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.



AB-QM and QT element makes the system a variable flow system, and secures good distribution of water flow to the radiators (No over and under heating). It saves energy and reduces the heating bill and the pumping cost.

For a low investment you get:

- Improved indoor comfort
- Reduction of energy cost
- Reliable heat allocation for more precise invoicing

Step 4b:
Selection and installation

Check the pressure and flow on the circulation pump. It should be set for constant pressure (if possible). The flow should be verified on the main balancing valve after setting all AB-QMs in the risers.

Commissioning
The values obtained in step 2 to 4 give you a clear overview of the (possible) issues in your heating system and are an indicator to optimize the system. Startup is easy after completion by installing AB-QM automatic balancing valves, by-pass restrictors and thermostatic radiator valves, because the radiator valves ensure the right temperature in the room, by-pass restrictors ensure the right resistance in each by-pass and right flow share through the by-pass and radiator and the AB-QM valves with QT elements automatically corrects the right flow according to the heat demand. No commissioning needed, only pump optimization.

Pump head setting should be suitable for the system (should not be too low or too high).

Commissioning guidelines
Determine average heat demand for radiators in the risers and pick setting according to table:

- OPTIMAL 1 pre-setting AB-QM
- Select size of automatic balancing valve AB-QM according to the table.
- Document the selected pre-setting of AB-QM (Commissioning protocol)
- Determine the flow through radiator using riser flow and alpha for specific radiator.
- Select RA-G thermostatic radiator valve the same size as the pipe OPTIMAL 1 RA-G SIZING

NOTE! Keep in mind that ALL radiators should be regulated through a thermostatic valve. This also applies to radiators in common areas like basements and staircases. It is not possible to leave out any radiators in this energy optimizing process. Make sure that the flow direction though the valve is proper.

- Decide together with the property owner and facility manager the room temperature limitations, and consider the need for thermostats with a remote sensor in case the thermostatic valve will be installed on the bottom pipe.
- Fill, flush and de-air the system.

Before commissioning

1. Check circulation pump rotation. If rotation is not correct, pump might not produce enough flow. Automatic circulation pump with automatic balancing valves in a system first should be set on constant dp characteristic
2. Check static pressure, it should be minimum: **Building height + 50 kPa (0,5 bar)**
3. Make sure system filter is clean: **Pressure loss (dP) filter should not exceed 3-5 kPa**
4. Set all balancing valves according balancing protocol. Setting has to be calculated according design flow. You cannot start measuring before all balancing valves are set.
5. Check if air from system is removed. If not, stop circulation pump and remove air.

Commissioning

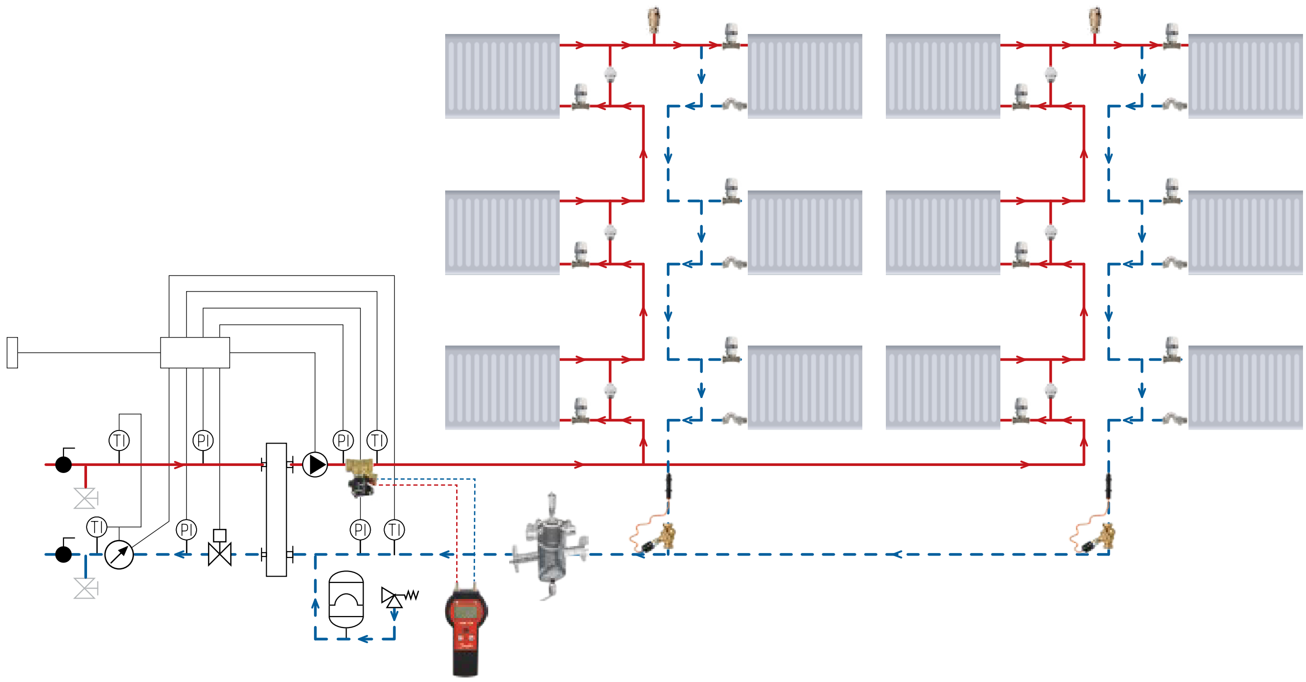
Commissioning method on the LAST BALANCING VALVE.

Fig 4: Measure, adjust and set points

Commissioning method on the MAIN BALANCING VALVE
Measure the flow over MSV-BD, MSV-F2 main manual balancing valve mounted on all systems. Lower pump head until flow drops below nominal.

Adjust circulating pump pressure so that the required ΔP is obtained on a critical raiser. Set pump for constant pressure (if possible).

Set the weather compensation curve of the controller (at the substation or boiler) on a reasonable value in relation to prior setting.



AB-QM and QT element makes the system a variable flow system, and secures good distribution of water flow to the radiators (no over and under heating). It saves energy and reduces the heating bill and the pumping cost.

For a low investment you get:
- Improved indoor comfort
- Reduction of energy cost
- Reliable heat allocation for more precise invoicing (if heat allocators are installed)

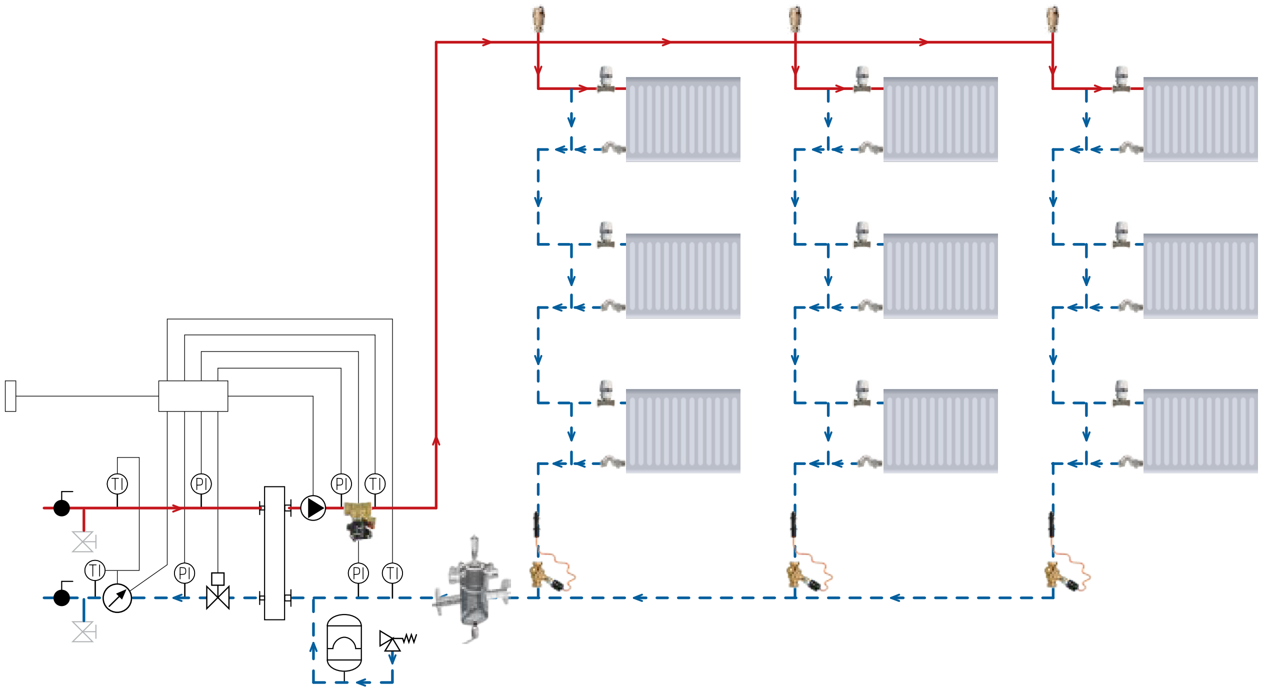
* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

After commissioning

Measure after a period of operation (about one month) flow and return temperature at the substation and at the risers in the system at the red marked locations. This should be done at lowest outdoor temperature as possible.

Check the temperatures; the goal is to have a ΔT according to **step 2 conclusion part.**

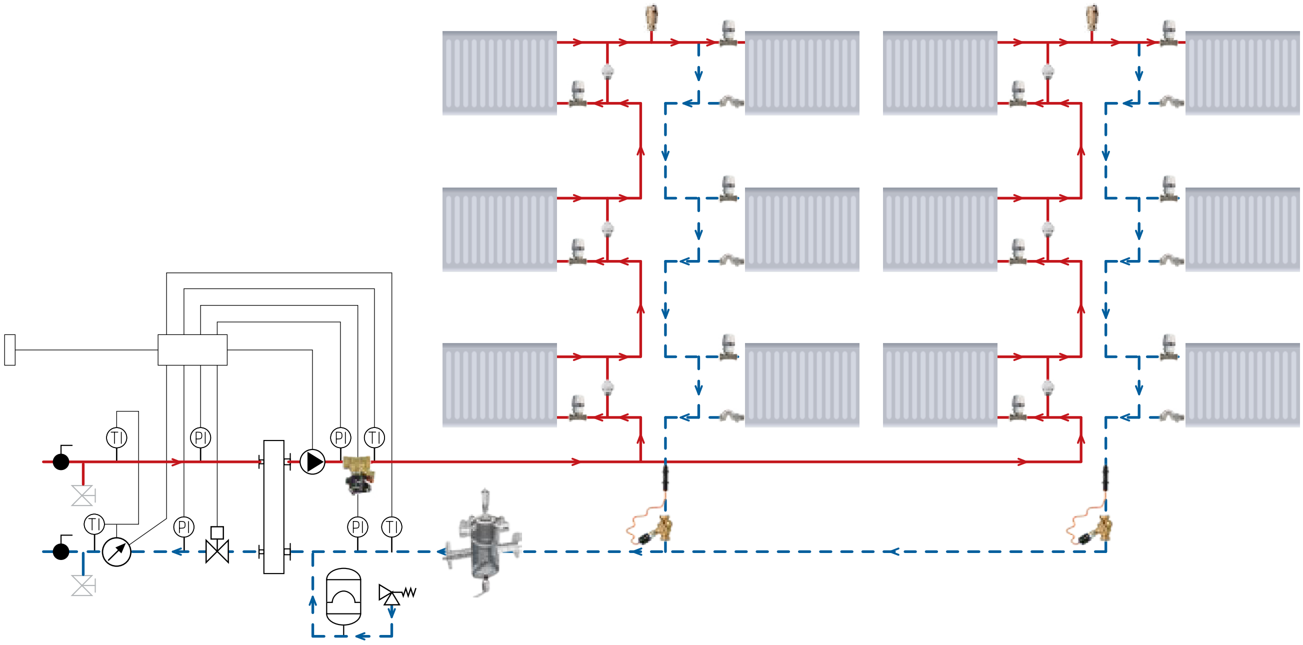
Check also if there is no noise at the system.



AB-QM and QT element makes the system a variable flow system, and secures good distribution of water flow to the radiators (no over and under heating). It saves energy and reduces the heating bill and the pumping cost.

For a low investment you get:
- Improved indoor comfort
- Reduction of energy cost
- Reliable heat allocation for more precise invoicing (if heat allocators are installed)

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

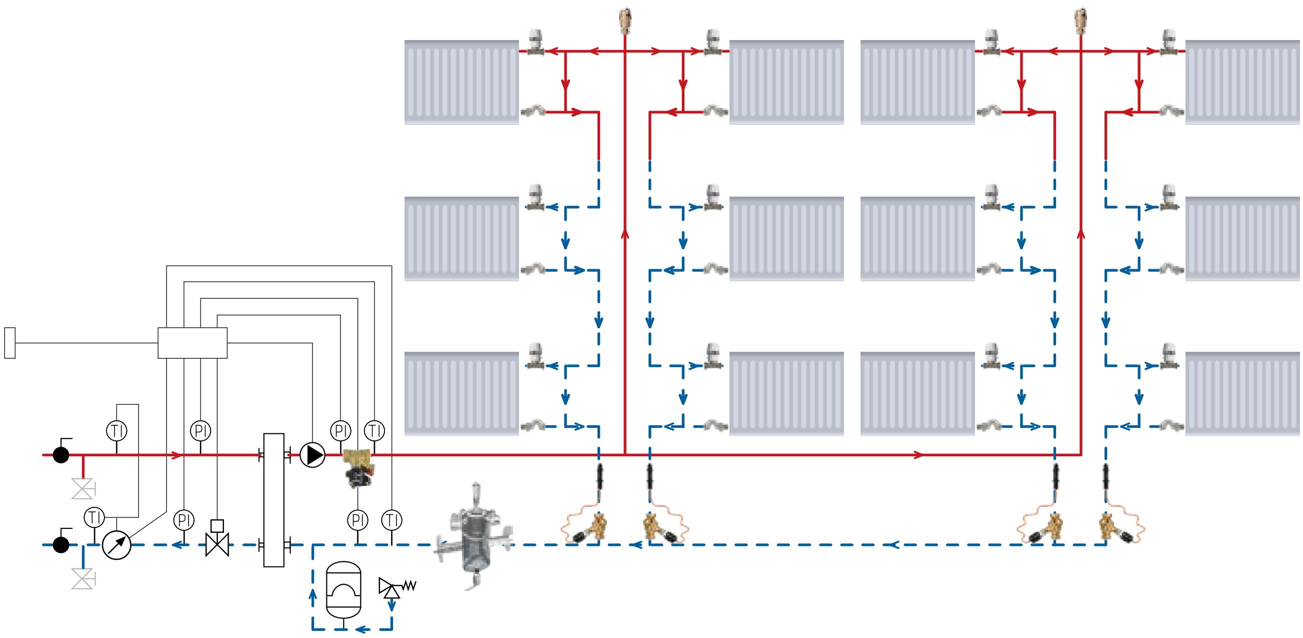


AB-QM and QT element makes the system a variable flow system, and secures good distribution of water flow to the radiators (no over and under heating). It saves energy and reduces the heating bill and the pumping cost.

For a low investment you get:

- Improved indoor comfort
- Reduction of energy cost
- Reliable heat allocation for more precise invoicing (if heat allocators are installed)

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

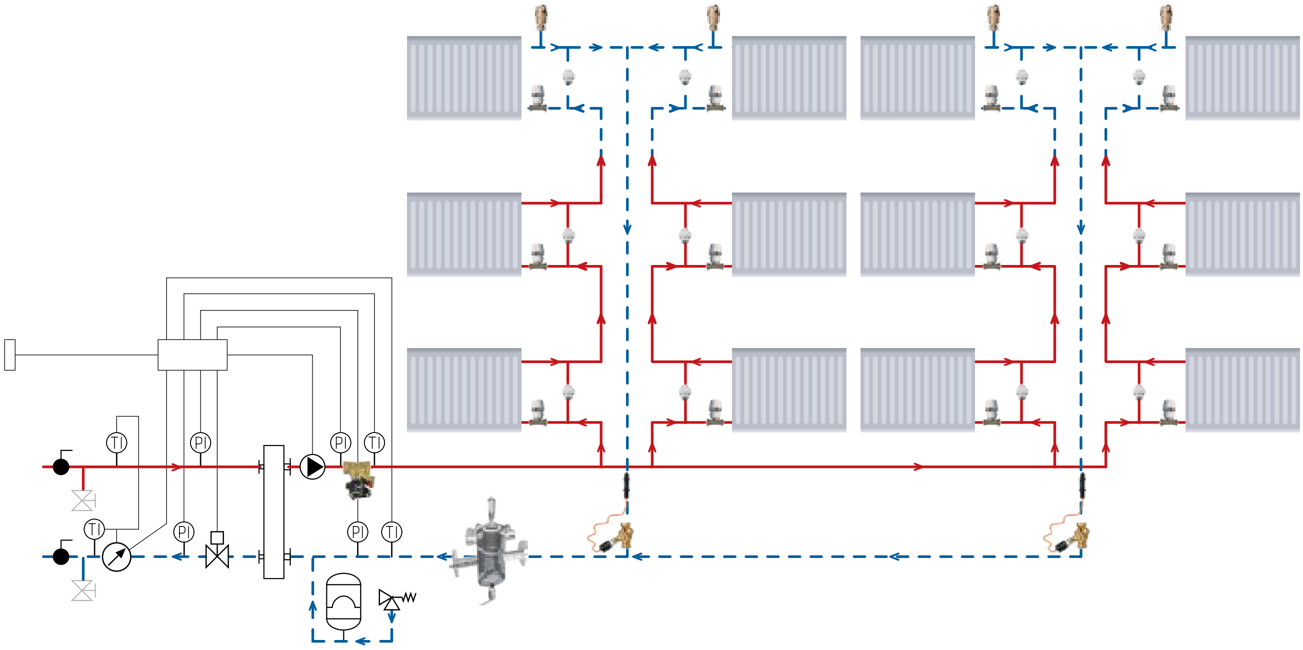


AB-QM and QT element makes the system a variable flow system, and secures good distribution of water flow to the radiators (no over and under heating). It saves energy and reduces the heating bill and the pumping cost.

For a low investment you get:

- Improved indoor comfort
- Reduction of energy cost
- Reliable heat allocation for more precise invoicing (if heat allocators are installed)

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.



Time	Outdoor Temp. °C (1)	Flow Temp. °C (2)	Return Temp.°C (top)(3)	Riser Temp. (Bottom) (4)	Riser Temp. (5)
06:00 hr.					
14:00 hr.					
22:00 hr.					

AB-QM and QT element makes the system a variable flow system, and secures good distribution of water flow to the radiators (no over and under heating). It saves energy and reduces the heating bill and the pumping cost.

For a low investment you get:

- Improved indoor comfort
- Reduction of energy cost
- Reliable heat allocation for more precise invoicing

* Note: this drawing is just a schematic, please check page 17 for more details about how the installation should look.

Return temperature setting on QT

The return temperature can be adjusted in eight points, each correspondent to one flow temperature.

Picture	Setting range	Fit to AB-QM	Code no.	Flow temp	QT recommended setting
	Setting range 45-60°C	DN10-20 DN25-32	003Z0382 003Z0383	90°C	58°C
				80°C	54°C
				70°C	48°C*
				63°C	45°C*
	Setting range 35-50°C	DN10-20 DN25-32	003Z0384 003Z0385	55°C	42°C
				50°C	40°C
				45°C	38°C
				40°C	35°C

*Setting range 35-50°C can be used for flow temperatures up to 70°C

QT setting – D_f Dynamic factor method

Temperature setting of the QT is influenced by dynamic factor D_f. Last radiator in the riser is normally the one which influences dynamic factor D_f at most. **D_f is to be selected from the table below**. Having dynamic factor selected, the correction value of return temperature can be chosen from picture bellow:

1. Calculate the Renovation effectiveness **Φ**:

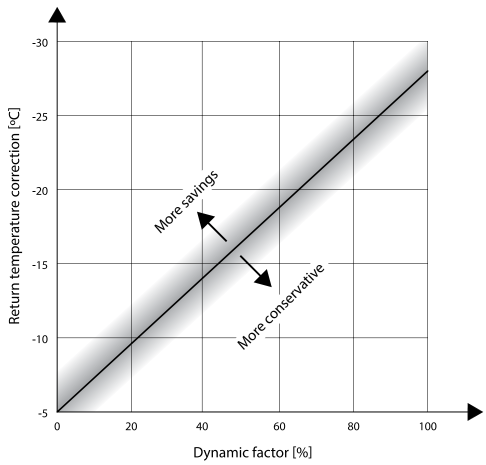
$$\phi_r = 100 \times \left(1 - \frac{Q_r}{Q_n}\right) [\%]$$

$[Q_n]$ - design heat losses (nominal)
$[Q_r]$ - actual heat losses (after renovation)

2. Select D_f from the table:

D_f – Dynamic Factor	Φr = renovation effectiveness [%]						
	0	10	20	30	40	50	60
3 W/m² internal gains (bedroom room, utility, other rooms)	8	19	31	43	54	66	78
9 W/m² internal gains (kitchen or living room)	17	29	41	52	64	76	88

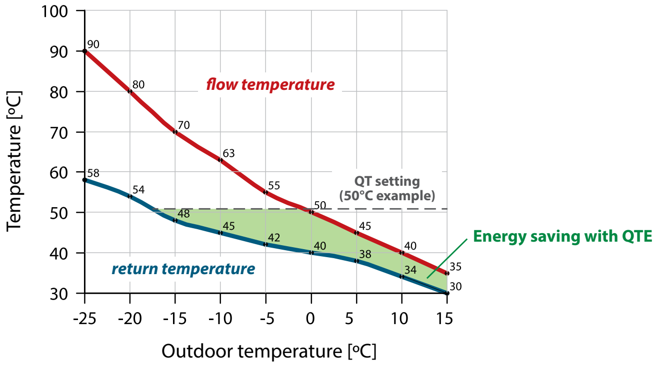
3. Selected for a particular building/riser, the correction value of return temperature can be chosen from the picture:



Return temperature setting on QTE

(Electronic return temperature control & temperature registration)

When return temperature increases CCR3 automatically detects this change and reduces flow in risers according to set points (lower load in risers – lower flow needed). Compared to self- acting solution (QT thermostatic elements), AB-QTE solution covers very wide temperature setting range, as presented on picture below:



The CCR3 return temperature can be adjusted in eight points, each correspondent to one flow temperature. CCR3 with temperature sensors and actuators are mounted on AB-QM controls flow in risers through the return temperature control (see application picture on page 23).

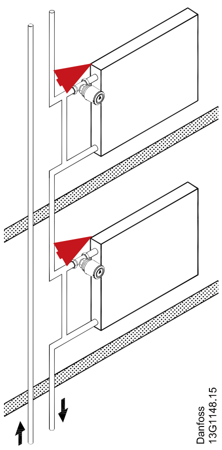
All points of return temperature setting correspond to supply temperature what allows automatic adaptation to weather condition according the rules: lower outside temperature, higher supply temperature – except higher return temperature, but all time optimized at any supply parameter.

The setting can be automatically applied for all risers or can be modified individually to each riser by:
Shift factor – allow to move up and down the curve in each point, setting range ±10 °C.

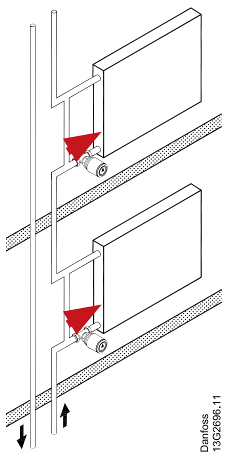
Note: For more details, please refer to CCR3 technical literature.

Mounting Thermostatic Radiator Valves

TRV mounting position, adjust sensor to required room temperature, you might need to set bottom mounted thermostat a bit lower to reach required temperature.



1. One-pipe system, flow from top



2. One-pipe system, flow from bottom

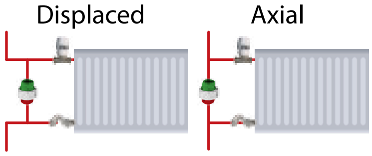
Note: Orientation of thermostat should be horizontal.

It is very important to choose TRVs the same size as the piping. The radiator connection might be smaller than pipes. To avoid hanging radiators (Cold radiators), we need to make sure control valves has as high kv-value as possible (Recommended Danfoss RA-G valve).

Recommendation for designers: to avoid noise, air, hanging radiators and back flow

Below matrix show alfa factor for two example of radiators (terminal units).

Recommended parameters for one-pipe calculation for P and T system



Criteria		Noise	Air	Hanging	Back flow	Beta/Alfa factor	Beta/Alfa factor
15/15/15	v max (m/s)	0,5	0,2 133	200 DN15: 40%	"Distance L > 300mm restrictor not obligatory"	0,28	0,24
	v rec (m/s)	0,3-0,4					
	v min (m/s)	x					
	Q max (l/h)	350					
	Q rec (l/h)	210-270					
	Q min (l/h)	x					
	AB-QM Q setting %	DN15: 45-60%					
	AB-QM Q max (l/h)	DN15: 75%					
20/15/20	v max (m/s)	0,5	0,2 245	150 DN20: 20%	"Distance L > 400mm restrictor not obligatory"	0,32	0,31
	v rec (m/s)	0,3-0,4					
	v min (m/s)	x					
	Q max (l/h)	350					
	Q rec (l/h)	210-270					
	Q min (l/h)	x					
	AB-QM Q setting %	DN15: 45-60%					
	AB-QM Q max (l/h)	DN15: 75%					
20/20/20	v max (m/s)	0,68	0,2 245	250 20%	"Distance L > 400mm restrictor not obligatory"	0,2	0,14
	v rec (m/s)	0,35-0,42					
	v min (m/s)	x					
	Q max (l/h)	810					
	Q rec (l/h)	450-550					
	Q min (l/h)	x					
	AB-QM Q setting %	DN20: 50-60%					
	AB-QM Q max (l/h)	DN20: 90%					
25/20/25	v max (m/s)	0,8	0,2 410	330 20%	"Distance L > 400mm restrictor not obligatory"	0,23	0,22
	v rec (m/s)	0,4-0,5					
	v min (m/s)	x					
	Q max (l/h)	1600					
	Q rec (l/h)	450-551					
	Q min (l/h)	x					
	AB-QM Q setting %	DN25: 20%					
	AB-QM Q max (l/h)	DN25: 95%					

v-flow velocity in riser; Q-flow in riser

Riser	Bypass	Radiator
15	15	15
20	20	20
20	15	20

OPTIMAL 1 pre-setting AB-QM

Example and recommendation for AB-QM selection. Presetting depending on load per store in the building: 500W, 1000W, 1500W

Data for different systems parameters:

65/50 after renovation Axial

"Average Radiator Heat, W"	AB-QM			"Storeys /Floors"	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
					Flow at radiator number																			
500	Flow l/h				29	57	86	115	143	172	201	229	258	287	315	344	373	401	430	459	487	516	545	573
	DN 10	"Max l/h"	275	"Pre-setting"	–	21	31	42	52	63	73	83	94	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	–	–	25	32	38	45	51	57	64	70	76	83	89	96	–	–	–	–	–
	DN 20		900		–	–	–	–	–	–	22	25	29	32	35	38	41	45	48	51	54	57	61	64
	DN 25		1700		–	–	–	–	–	–	–	–	–	–	–	20	22	24	25	27	29	30	32	34
1000	Flow l/h				57	115	172	229	287	344	401	459	516	573	631	688	745	803	860	917	974	1032	1089	1146
	DN 10	"Max l/h"	275	"Pre-setting"	21	42	63	83	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	25	38	51	64	76	89	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	–	25	32	38	45	51	57	64	70	76	83	89	96	–	–	–	–	–
	DN 25		1700		–	–	–	–	–	20	24	27	30	34	37	40	44	47	51	54	57	61	64	67
1500	Flow l/h				86	172	258	344	430	516	602	688	774	860	946	1032	1118	1204	1290	1376	1462	1548	1634	1720
	DN 10	"Max l/h"	275	"Pre-setting"	31	63	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	38	57	76	96	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	29	38	48	57	67	76	86	96	–	–	–	–	–	–	–	–	–	–
	DN 25		1700		–	–	–	20	25	30	35	40	46	51	56	61	66	71	76	81	86	91	96	–

(dark blue)	Accepted – automatic air remover required
(green)	Recommended
(light pink)	Forbidden (Noise)
Red text	Flow from bottom requires by-pass restrictors

65/50 after renovation Displaced

"Average Radiator Heat, W"	AB-QM			"Storeys /Floors"	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
					Flow at radiator number																			
500	Flow l/h				29	57	86	115	143	172	201	229	258	287	315	344	373	401	430	459	487	516	545	573
	DN 10	"Max l/h"	275	"Pre-setting"	–	21	31	42	52	63	73	83	94	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	–	–	25	32	38	45	51	57	64	70	76	83	89	96	–	–	–	–	–
	DN 20		900		–	–	–	–	–	–	22	25	29	32	35	38	41	45	48	51	54	57	61	64
	DN 25		1700		–	–	–	–	–	–	–	–	–	–	–	20	22	24	25	27	29	30	32	34
1000	Flow l/h				57	115	172	229	287	344	401	459	516	573	631	688	745	803	860	917	974	1032	1089	1146
	DN 10	"Max l/h"	275	"Pre-setting"	21	42	63	83	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	25	38	51	64	76	89	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	–	25	32	38	45	51	57	64	70	76	83	89	96	–	–	–	–	–
	DN 25		1700		–	–	–	–	–	20	24	27	30	34	37	40	44	47	51	54	57	61	64	67
1500	Flow l/h				86	172	258	344	430	516	602	688	774	860	946	1032	1118	1204	1290	1376	1462	1548	1634	1720
	DN 10	"Max l/h"	275	"Pre-setting"	31	63	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	38	57	76	96	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	29	38	48	57	67	76	86	96	–	–	–	–	–	–	–	–	–	–
	DN 25		1700		–	–	–	20	25	30	35	40	46	51	56	61	66	71	76	81	86	91	96	–

(dark blue)	Accepted – automatic air remover required
(green)	Recommended
(light pink)	Forbidden (Noise)
Red text	Flow from bottom requires by-pass restrictors

80/60 after renovation Axial

"Average Radiator Heat, W"	AB-QM			"Storeys /Floors"	Flow at radiator number																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
500	Flow l/h				21	43	64	86	107	129	150	172	193	215	236	258	279	301	322	344	365	387	408	430
	DN 10	"Max l/h"	275	"Pre-setting"	–	–	23	31	39	47	55	63	70	78	86	94	–	–	–	–	–	–	–	–
	DN 15		450		–	–	–	–	24	29	33	38	43	48	53	57	62	67	72	76	81	86	91	96
	DN 20		900		–	–	–	–	–	–	–	–	21	24	26	29	31	33	36	38	41	43	45	48
	DN 25		1700		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20	21	23	24	25
1000	Flow l/h				43	86	129	172	215	258	301	344	387	430	473	516	559	602	645	688	731	774	817	860
	DN 10	"Max l/h"	275	"Pre-setting"	–	31	47	63	78	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	–	29	38	48	57	67	76	86	96	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	–	–	24	29	33	38	43	48	53	57	62	67	72	76	81	86	91	96
	DN 25		1700		–	–	–	–	–	–	–	20	23	25	28	30	33	35	38	40	43	46	48	51
1500	Flow l/h				64	129	193	258	322	387	451	516	580	645	709	774	838	903	967	1032	1096	1161	1225	1290
	DN 10	"Max l/h"	275	"Pre-setting"	23	47	70	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	29	43	57	72	86	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	21	29	36	43	50	57	64	72	79	86	93	–	–	–	–	–	–	–
	DN 25		1700		–	–	–	–	–	23	27	30	34	38	42	46	49	53	57	61	64	68	72	76

Accepted – automatic air remover required

Recommended

Forbidden (Noise)

Red text Flow from bottom requires by-pass restrictors

80/60 after renovation Displaced

"Average Radiator Heat, W"	AB-QM			"Storeys /Floors"	Flow at radiator number																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
500	Flow l/h				21	43	64	86	107	129	150	172	193	215	236	258	279	301	322	344	365	387	408	430
	DN 10	"Max l/h"	275	"Pre-setting"	–	–	23	31	39	47	55	63	70	78	86	94	–	–	–	–	–	–	–	–
	DN 15		450		–	–	–	–	24	29	33	38	43	48	53	57	62	67	72	76	81	86	91	96
	DN 20		900		–	–	–	–	–	–	–	–	21	24	26	29	31	33	36	38	41	43	45	48
	DN 25		1700		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20	21	23	24	25
1000	Flow l/h				43	86	129	172	215	258	301	344	387	430	473	516	559	602	645	688	731	774	817	860
	DN 10	"Max l/h"	275	"Pre-setting"	–	31	47	63	78	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	–	29	38	48	57	67	76	86	96	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	–	–	24	29	33	38	43	48	53	57	62	67	72	76	81	86	91	96
	DN 25		1700		–	–	–	–	–	–	–	20	23	25	28	30	33	35	38	40	43	46	48	51
1500	Flow l/h				64	129	193	258	322	387	451	516	580	645	709	774	838	903	967	1032	1096	1161	1225	1290
	DN 10	"Max l/h"	275	"Pre-setting"	23	47	70	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	29	43	57	72	86	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	21	29	36	43	50	57	64	72	79	86	93	–	–	–	–	–	–	–
	DN 25		1700		–	–	–	–	–	23	27	30	34	38	42	46	49	53	57	61	64	68	72	76

Accepted – automatic air remover required

Recommended

Forbidden (Noise)

Red text Flow from bottom requires by-pass restrictors

95/70 after renovation Axial

"Average Radiator Heat, W"	AB-QM			"Storeys /Floors"	Flow at radiator number																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
500	Flow l/h				17	34	52	69	86	103	120	138	155	172	189	206	224	241	258	275	292	310	327	344
	DN 10	"Max l/h"	275	"Pre-setting"	–	–	–	25	31	38	44	50	56	63	69	75	81	88	94	–	–	–	–	–
	DN 15		450		–	–	–	–	–	23	27	31	34	38	42	46	50	54	57	61	65	69	73	76
	DN 20		900		–	–	–	–	–	–	–	–	–	–	21	23	25	27	29	31	32	34	36	38
	DN 25		1700		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20
1000	Flow l/h				34	69	103	138	172	206	241	275	310	344	378	413	447	482	516	550	585	619	653	688
	DN 10	"Max l/h"	275	"Pre-setting"	–	25	38	50	63	75	88	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	–	23	31	38	46	54	61	69	76	84	92	99	–	–	–	–	–	–	–
	DN 20		900		–	–	–	–	–	23	27	31	34	38	42	46	50	54	57	61	65	69	73	76
	DN 25		1700		–	–	–	–	–	–	–	–	–	20	22	24	26	28	30	32	34	36	38	40
1500	Flow l/h				52	103	155	206	258	310	361	413	464	516	567	619	671	722	774	825	877	929	980	1032
	DN 10	"Max l/h"	275	"Pre-setting"	–	38	56	75	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	23	34	46	57	69	80	92	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	–	23	29	34	40	46	52	57	63	69	75	80	86	92	97	–	–	–
	DN 25		1700		–	–	–	–	–	–	21	24	27	30	33	36	39	42	46	49	52	55	58	61

Accepted – automatic air remover required

Recommended

Forbidden (Noise)

Red text — Flow from bottom requires by-pass restrictors

95/70 after renovation Displaced

"Average Radiator Heat, W"	AB-QM			"Storeys /Floors"	Flow at radiator number																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
500	Flow l/h				17	34	52	69	86	103	120	138	155	172	189	206	224	241	258	275	292	310	327	344
	DN 10	"Max l/h"	275	"Pre-setting"	–	–	–	25	31	38	44	50	56	63	69	75	81	88	94	–	–	–	–	–
	DN 15		450		–	–	–	–	–	23	27	31	34	38	42	46	50	54	57	61	65	69	73	76
	DN 20		900		–	–	–	–	–	–	–	–	–	–	21	23	25	27	29	31	32	34	36	38
	DN 25		1700		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20
1000	Flow l/h				34	69	103	138	172	206	241	275	310	344	378	413	447	482	516	550	585	619	653	688
	DN 10	"Max l/h"	275	"Pre-setting"	–	25	38	50	63	75	88	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	–	23	31	38	46	54	61	69	76	84	92	99	–	–	–	–	–	–	–
	DN 20		900		–	–	–	–	–	23	27	31	34	38	42	46	50	54	57	61	65	69	73	76
	DN 25		1700		–	–	–	–	–	–	–	–	–	20	22	24	26	28	30	32	34	36	38	40
1500	Flow l/h				52	103	155	206	258	310	361	413	464	516	567	619	671	722	774	825	877	929	980	1032
	DN 10	"Max l/h"	275	"Pre-setting"	–	38	56	75	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	DN 15		450		–	23	34	46	57	69	80	92	–	–	–	–	–	–	–	–	–	–	–	–
	DN 20		900		–	–	–	23	29	34	40	46	52	57	63	69	75	80	86	92	97	–	–	–
	DN 25		1700		–	–	–	–	–	–	21	24	27	30	33	36	39	42	46	49	52	55	58	61

Accepted – automatic air remover required

Recommended

Forbidden (Noise)

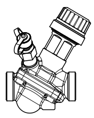
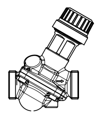
Red text — Flow from bottom requires by-pass restrictors

Flow presetting helps to distribute water flow through risers. It enables the system to deliver the variable need for heat to be matched with the variable supply of energy for optimal comfort and energy savings.

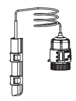
Optimal 1 **RA-G** sizing

Type	Code no.	Design	Connection ISO 7-1		Kv - values [m³/h] P-Band [K]				
			Inlet	Outlet	0.5	1.0	1.5	2.0	Kvs
RA-G 15	**013G1676** **013G1675**	Angle Straight	Rp ½	R ½	0.54 0.51	1.07 0.94	1.61 1.35	2.06 1.63	4.30 2.30
RA-G 20	**013G1678** **013G1677**	Angle Straight	Rp ¾	R ¾	0.57 0.54	1.11 1.07	1.16 1.61	2.20 2.06	5.01 3.81
RA-G 25	**013G1680** **013G1679**	Angle Straight	Rp 1	R 1	0.59 0.57	1.27 1.16	1.77 1.71	2.41 2.27	5.50 4.58

AB-QM valves

Picture	DN	Qmax (l/h)	Ext. Thread (ISO 228/1)	Code no.	AB-QM	Ext. Thread (ISO 228/1)	Code no.
	10 LF	150	G ½ A	**003Z1261**		G ½ A	**003Z1251**
	10	275		**003Z1211**			**003Z1201**
	15 LF	275	G ¾ A	**003Z1262**		G ¾ A	**003Z1252**
	15	450		**003Z1212**			**003Z1202**
	20	900	G 1 A	**003Z1213**		G 1 A	**003Z1203**
	25	1700	G ¼ A	**003Z1214**		G ¼ A	**003Z1204**
	32	3200	G ½ A	**003Z1215**		G ½ A	**003Z1205**

QT thermostatic actuator

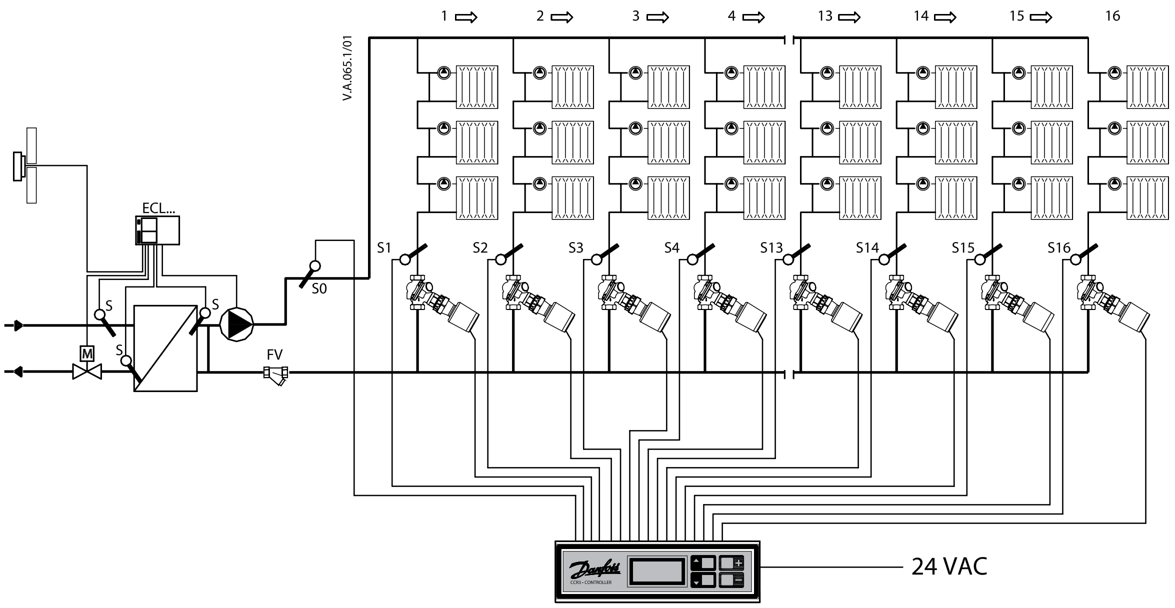
Picture	Setting range (°C)	Fit to AB-QM	Code no.
	45 … 60	DN 10-20	**003Z0382**
		DN 25-32	**003Z0383**
	35 … 50	DN 10-20	**003Z0384**
		DN 25-32	**003Z0385**

AB-QTE electronic one-pipe solution

for full control of one-pipe heating system. With AB-QM + CCR3 + TWA-Z + ESMC.

Benefits CCR3 electronic controller:

- Full control based on the outside temperature
- Perfect hydronic balance at all load conditions: reliable heating system that results with even heat distribution and no under-heating claims
- each riser/loop becomes independent part of the heating system
- reduced heat losses in the pipes due to low return temperature
- less overheating of the rooms due to vastly improved indoor temperature control
- Best energy efficiency: AB-QTE saves energy throughout the heating season
- Electronic & central monitoring, service and resetting of each individual riser



Ordering

Type	Description	Voltage	Sensor/Actuator type	Code no.
CCR3 controller	Return Temperature controller & Temperature Registration	24V AC	NO/16 pcs	003Z0389
TWA-Z (NO)	Thermal actuator	24V AC	1,2 m cable	082F1220
ESMC (PT1000)	Surface sensor	-	2 m cable	087N0011
Set of TWA & ESMC	Thermal actuator/Surface sensor	24V AC	-	003Z0388

For details on AB-QM, TWA-Z, ESMC and CCR3 controllers please contact your local Danfoss A/S sales office.

ENGINEERING TOMORROW

See you at hbc.danfoss.com

Danfoss Commercial Controls' first point of contact can be found on the internet. At **hbc.danfoss.com** or one of the many local websites you can find a complete toolbox of supporting materials. These tools can help you to make the best product selection for each of your projects. Find the best suitable product with the right dimensions and prepare the right setting to make the job on site as easy as possible.

On our website you can find:

Literature
Both commercial and technical literature, like brochures, case stories and technical datasheets will help you find the best products for your projects.

Tools
Videos and animations help you to better understand our products. Calculation tools and software will help you to commission on site.

Social media
Besides visiting our websites you can also follow us on social media. At **youtube.com/DanfossHeating** you can find our videos. Just click on 'Hydronic Balancing & Control'.

Or stay up to date by following us on Twitter at **twitter.com/DanfossBalance**

Presetting App
A handy Mobile App for all HVAC professionals can be downloaded from iTunes or Google Play store.

Scan QR code to see the AB-QT whiteboard animation

This animation demonstrates how balancing valves can be a great solution to improve the performance of a one-pipe heating system and reduce costs at the same time.

Danfoss A/S · Ulvehavevej 61 · 7100 Vejle · Denmark
Tel.: +45 7488 8500 · Email: heating@danfoss.com · www.heating.danfoss.com