ENGINEERING
TOMORROW

Optimal 2 Tool

Design and commission a two-pipe radiator system **in an easier way**

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Introduction

The Optimal 2 tool is based on the combination of two Danfoss products: automatic balancing valves (ASV) and thermostatic radiator valves (RA-N), used for renovation in residential heating systems.

This Optimal 2 tool focuses on:

- Designing a two-pipe radiator heating system in a cost efficient way.
- Selection and simplified sizing of balancing valves and thermostatic radiator valves.
- Commissioning.

Why use Optimal 2 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 30% by installing thermostatic radiator valves + dynamic balancing valves can be achieved with an average payback time of less than 3 years!

The Optimal 2 tool is developed to improve the hydronic balance in an existing heating system, but without detailed calculations. The tool will help to:

- Correct pressure and 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!)

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

About Optimal 2

Optimal 2 is a tool that enables you to get control over your radiators and automatic balancing valves in a two-pipe heating system. With this tool you will – in a very easy way– be able to select the right radiator and balancing valves and get the right information to pre-set both type of valves.

The purpose of commissioning is to get the most optimal 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 differential pressure over radiators and risers even at partial load conditions.

A proper difference in temperature between flow and return, also referred to as ΔT, means that the right amount of water goes through the radiator. This improves the efficiency of the boiler and consequently the indoor temperature.

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

Step 1:
Analyze the two-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 radiator is heated)
- ☐ unfair billing regardless heat cost allocators (differences between similar apartments)
- ☐ other ....

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

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. 2011/2012) .... ☐ GJ/ ☐ m^3

Heating season ....../...... (e.g. 2012/2013) .... ☐ GJ/ ☐ m^3

Heating season ....../...... (e.g. 2013/2014) .... ☐ GJ/ ☐ m^3

Any other issues with the heating system that might be relevant:

....

....

....

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

- ☐ **A** No balancing valves at all
- ☐ **B** Radiator valves with pre-setting
- ☐ **C** Manual balancing valves
- ☐ **D** Other (flow limiters, orifices)
- ☐ **E** Differential pressure controllers (automatic balancing valves)

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

- ☐ Yes
- ☐ Yes, but only presetting on radiator valves have been done
- ☐ 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 two-pipe radiator system should be optimized.

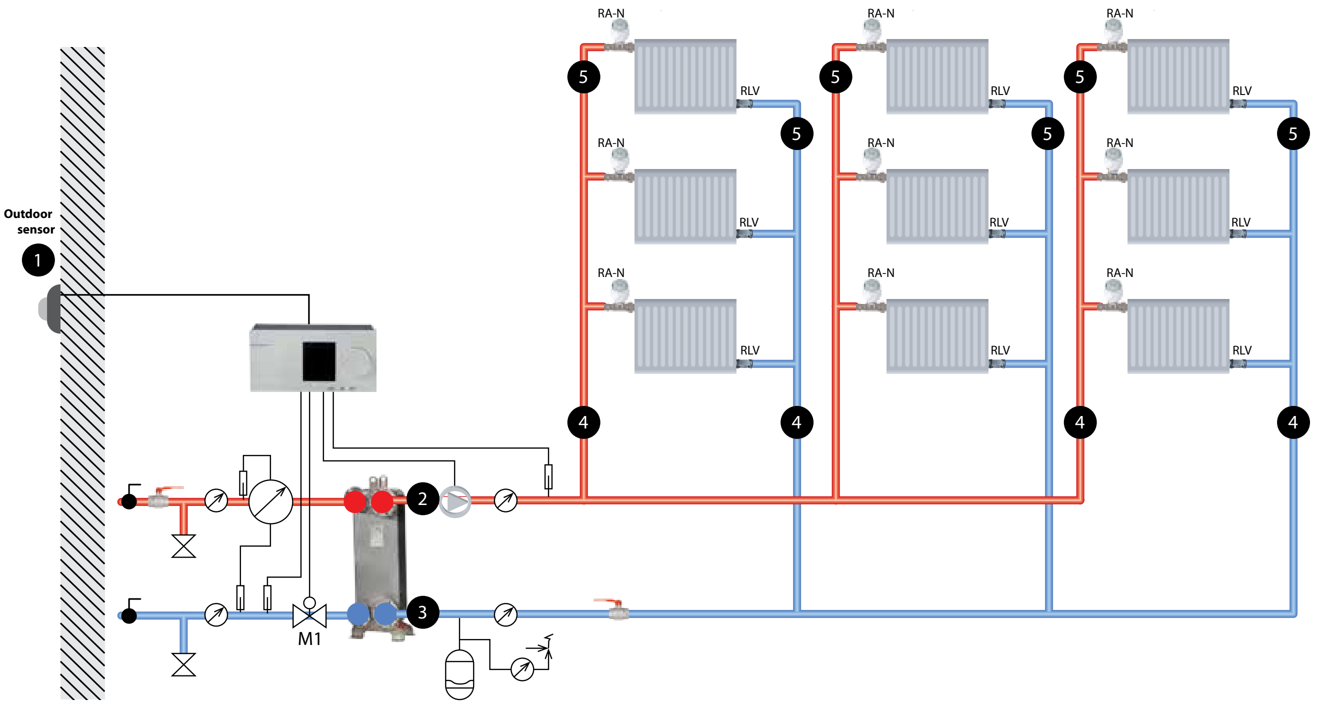
Proceed to Step 2.

Step 2:
Measure and record

Please **measure** and record the following temperatures 3 times during one day (if possible).
The exact measure points are marked with a number in the drawing below.

- the current outdoor temperature ❶
- the outgoing flow temperature of the condensing boiler / heat exchanger ❷
- the outgoing return temperature on condensing boiler / heat exchanger ❸
- the flow and return temperature on the bottom of the first and last riser ❹
- the flow and return temperature on the last radiator in each riser ❺

Fig 1: Measuring points



	Outdoor Temp. in °C ❶	Flow Temp. in °C ❷	Return Temp. in °C ❸
06.00 hr.	---------------------------	---------------------------	---------------------------
14.00 hr.	---------------------------	---------------------------	---------------------------
22.00 hr.	---------------------------	---------------------------	---------------------------

Step 2a:
Add the measuring results in the graph

Choose a day with as low outdoor temperature as possible. Measured 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 2: Temperature measurements

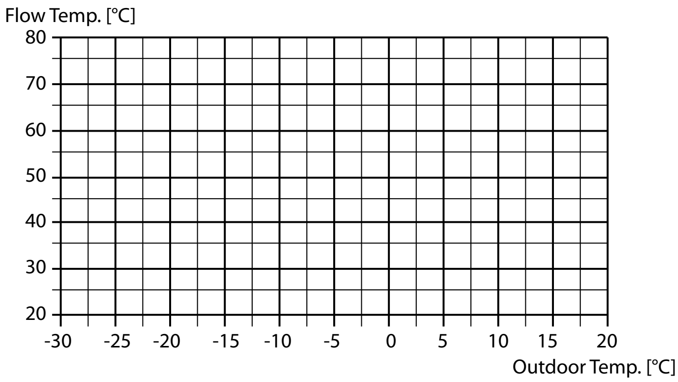
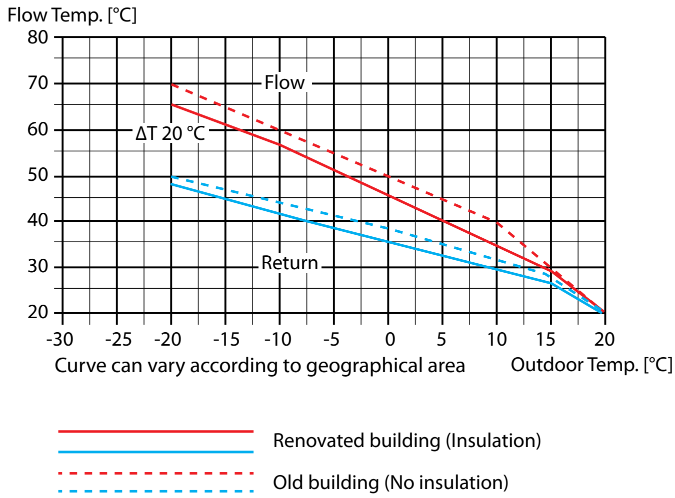


Fig 3: Example



Conclusion

- ☐ Is measured temperature difference (ΔT) lower than 20 °C (design ΔT) ? If yes, consider system optimization.
- ☐ Is measured temperature difference (ΔT) higher than 20 °C ? If yes, the system is properly balanced.
- ☐ In case you have a large temperature drop in distribution lines check the pipe insulation.

Step 3:
Optimize the heat curve

Open the controller at the Heat source (substation/boiler etc…) and read the curve setting.

Change and correct (if needed) the heat curve 'parallel shift' in the controller at the substation according to the optimal heat curve.

Renovated building (Insulation)

Old building (No insulation)

Step 4:
Selection and installation

Check the pressure and flow on the circulation pump. It should be set for constant pressure. The minimum pressure of the pump should cover the pressure drop in the critical loop. Please check available pressure with all thermostats open or dismantled.

Conclusion
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 ASV automatic balancing valves and thermostatic radiator valves, because the radiator valves ensure the right flow through each radiator and the ASV-PV valves automatically eliminate the pressure fluctuations caused by the changing heat demand. No commissioning needed, only pump optimization.

Commissioning – mounting

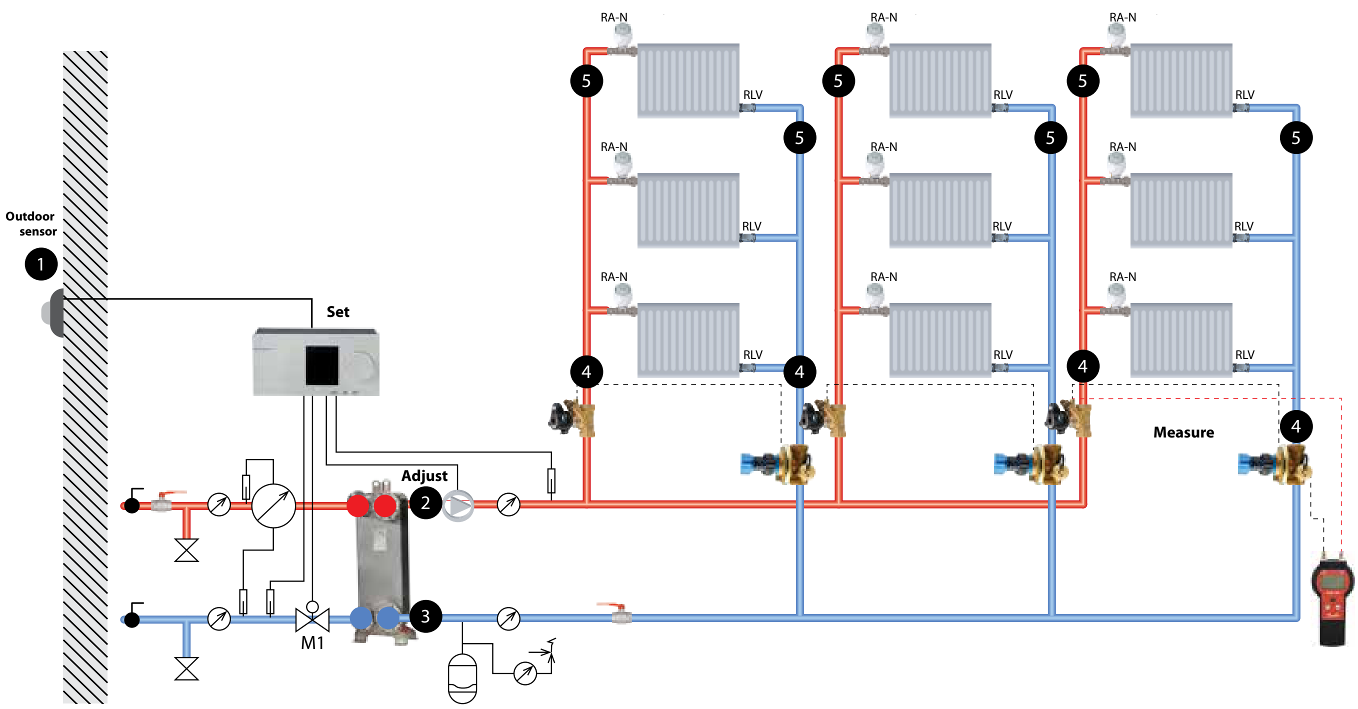
- Obtain drawings by room surfaces given in m^2, of all apartments in the building. When drawings are not available, please measure the areas.
- Determine the pre-setting values for each radiator valve according to the size of each room and the information from the table: FIG. 6 PRE-SETTING VALUES RA-N AND RA-U.
- Document the selected pre-setting (Commissioning protocol)
- Decide together with the property owner and facility manager the room temperature limitations, and consider the need for thermostats with a remote sensor.
- Select type of differential pressure controller (fixed ΔP 10 kPa ASV-P or adjustable 5-25 kPa ASV-PV) according to the table: FIG. 7 DIFFERENTIAL PRESSURE CONTROLLER. Note the required ΔP for ASV-P(V). Select the valve size, this should be the same size as the riser dimension, or in the case that existing valves have smaller dimension than the riser, select this dimension.

  NOTE! Keep in mind that ALL radiators must be regulated through an ASV valve. This also applies to radiators in common areas like basements. It is not possible to leave out any radiators in this energy optimizing process.
- Mount differential pressure controllers.
- Pre-set radiator valves. Pre-set ASV-PV valves in all risers.
- Fill, flush and de-air the system.

Commissioning

- **Measure** the differential pressure over the last riser (Between drain on ASV-P/PV (mount adapter for differential pressure measurement 003L8273) and ASV-BD on the riser. Lower pump head until set pressure is lost, increase pump head a few steps back to get set value.
- **Adjust** circulating pump pressure so that the required ΔP is obtained. In case of renovation remember to fully open the thermostats.
- Mount radiator thermostats.
- **Set** the curve of the controller (at the substation) on a reasonable value in relation to prior setting.

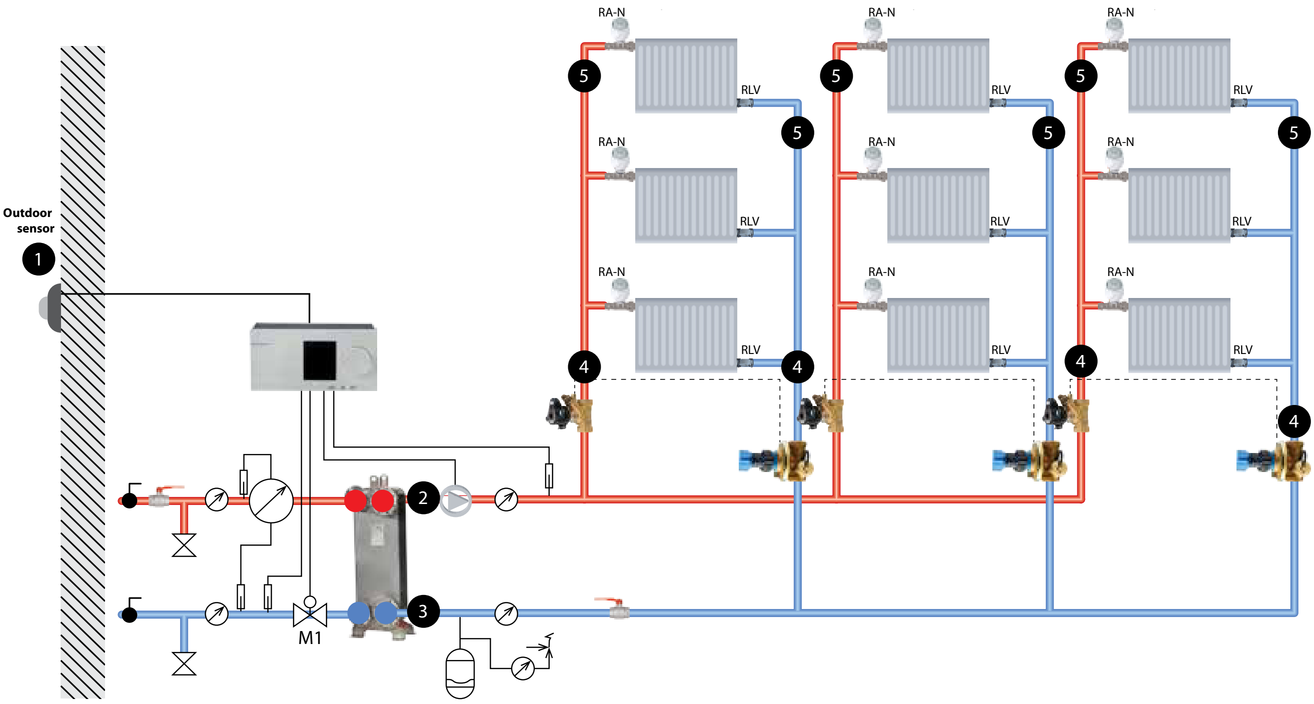
Fig 4: Measure, adjust and set points



Follow-up

- **Measure** after a period of operation (about 1 month) flow and return temperature at the substation, the final riser and the final radiator in the system at the orange marked locations. This should be done at lowest outdoor temperature as possible (In the morning).
- Check the temperatures the goal is to have a ΔT according to **step 2 conclusion.**

Fig 5: Temperature measurements



Pre-setting RA-N and RA-U valves

Pre-setting helps to distribute water flow through radiators. 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.

Examples:
In case there are multiple radiators in the same room, please read below given example.

Example: In a 24m² room there are **two equally** sized radiators. Then, the pre-setting on the respective radiators should be done for 12m² each. When radiators have **different** sizes the pre-setting should be adjusted based on the radiator sizes.

Some rooms are located in colder places, for example rooms situated in a corner with outside walls, or directly underneath a roof or above a cold, unheated floor. These rooms require a bit more heating compared to a room situated in the middle of a building to get the same indoor comfort. See columns with additional settings in **Fig 6.**

Elderly persons or people that are sick also require some additional degrees Celsius in order to experience the same indoor comfort as young, healthy, active individuals.

Fig 6: Pre-setting values RA-N and RA-U

Floor m²	<6	12	18	24	Setting	Additional setting:
					Bathroom and toilet without windows	**Corner rooms (each corner), roofs and/or cold floors**
RA-N 10	2	2,5	4	5	1,5-2	0,5
RA-N 15	2	2,5	3,5	4	1,5-2	0,5
RA-N 20	-	2	2,5	3	-	0,5
RA-U 10/15	2,5	4	5	6	3-3,5	0,5

(ΔT 20 °C, ΔP 7 kPa, 60 W/m²)

Differential pressure controllers ASV-P or ASV-PV

ASV (differential pressure controller) keeps the required differential pressure (ΔP) constant across the respective riser. The required ΔP (kPa) is calculated by the resistance in the pipes in the respective riser, thermostatic valve and radiator.

Examples:
The resistance of the pipes varies with the length of the pipes. 10 kPa is sufficient for 10 storey building with ceiling heights of 3 meters above the horizontal distribution pipe, meaning both ASV-P (fixed 10 kPa setting) or ASV-PV (adjustable setting) can be chosen (see green marked boxes).

For a low or a high building up to 3 storeys high or above 10 storeys high , the ASV-PV would be the only correct choice (see green marked boxes). This valve is adjustable from 5 to 25 kPa. The kPa setting can be done according to the given settings in below table (**Fig 7**).

The recommended ASV valve type is marked with **green** in the table.

Fig 7: Differential pressure controller

Number of floors (3 m.) above distribution lines	Required ΔP setting (kPa)	ASV-P 10 kPa	ASV-PV 5-25 kPa
Basement and ground floor	8 kPa		
2-3	9 kPa		
4-5	10 kPa		
6-7	11 kPa		
8	12 kPa		
9-10	13 kPa		
11-12	14 kPa		

- ΔP 7 kPa over thermostatic radiator valve
- ΔP 0,6 kPa inside pipes per storey of 3 meters

Dimensioning

ASV-PV + ASV-BD valves are selected after the calculated water flow and are usually the same as the pipe size.

Buildings from around the year 1920......... 100-160 W/m²

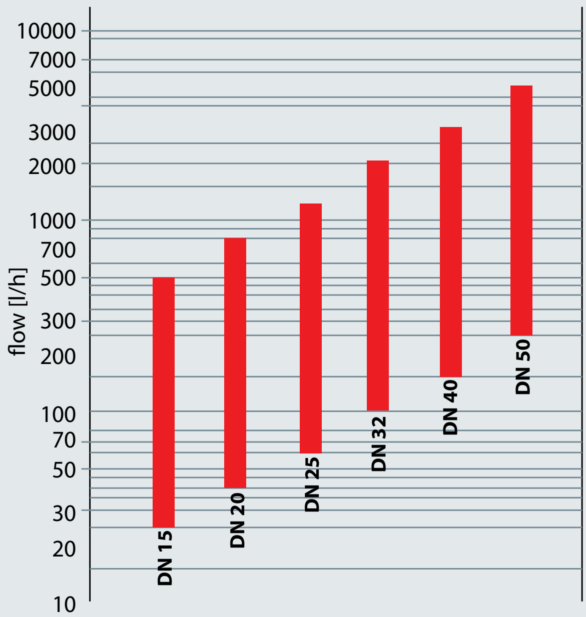
Buildings from around the year 1940......... 90-150 W/m²

Buildings from around the year 1960......... 60-80 W/m²

Buildings from around the year 1980......... 40-55 W/m²

Buildings from around the year 2000......... 20-45 W/m²

Buildings from around the year 2006......... 15-35 W/m²



Sizing Diagram

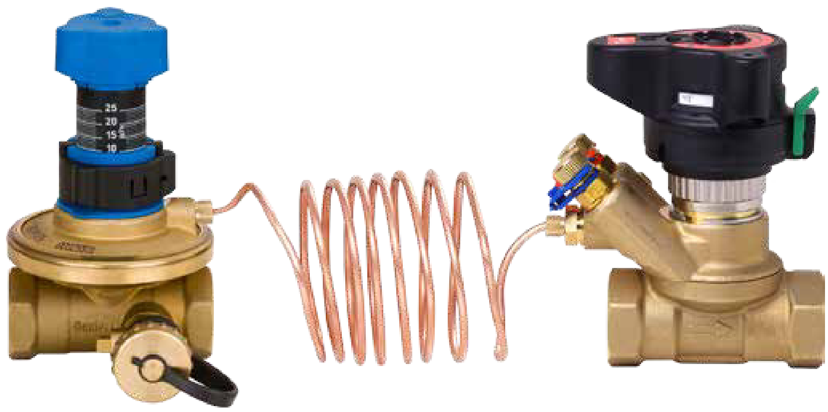
Formula:

$$\frac{W \times m^2 \times 0.86}{\text{Delta T}} = X \text{ l/h}$$

Example:
With a heated floor space of 78 m², a consumption of 60 W/m² and a temperature drop (ΔT) of 20 °C, you will need ~ 200 liter water per hour in the distribution pipe.

$$\frac{60 \times 78 \times 0{,}86}{20} = 200 \text{ l/h}$$

See sizing diagram: for 200 l/h select ASV set DN 15 or 20.



ASV product range

Type	Code nr	Function	Max. effect	Max. flow
ASV-PV DN 15	003Z5601	• Differential pressure controller • Shut off	20 kW	500 l/h
ASV-PV DN 20	003Z5602	• Differential pressure controller • Shut off	30 kW	800 l/h
ASV-PV DN 25	003Z5603	• Differential pressure controller • Shut off	50 kW	1300 l/h
ASV-PV DN 32	003Z5604	• Differential pressure controller • Shut off	70 kW	2000 l/h
ASV-PV DN 40	003Z5605	• Differential pressure controller • Shut off	110 kW	3200 l/h
ASV-P DN 15	003L7621	• Differential pressure controller • Shut off	20 kW	500 l/h
ASV-P DN 20	003L7622	• Differential pressure controller • Shut off	30 kW	800 l/h
ASV-P DN 25	003L7623	• Differential pressure controller • Shut off	50 kW	1300 l/h
ASV-P DN 32	003L7624	• Differential pressure controller • Shut off	70 kW	2000 l/h
ASV-P DN 40	003L7625	• Differential pressure controller • Shut off	110 kW	3200 l/h
ASV-BD DN 15	003Z4041	• Flow verification • Trouble shooting • Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-BD DN 20	003Z4042	• Flow verification • Trouble shooting • Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-BD DN 25	003Z4043	• Flow verification • Trouble shooting • Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-BD DN 32	003Z4044	• Flow verification • Trouble shooting • Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-BD DN 40	003Z4045	• Flow verification • Trouble shooting • Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-M DN 15	003L7691	• Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-M DN 20	003L7692	• Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-M DN 25	003L7693	• Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-M DN 32	003L7694	• Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
ASV-M DN 40	003L7695	• Shut off	Same dimension as ASV-PV	Same dimension as ASV-PV
PFM 100	003L8260	Measuring instrument for pump optimization	-	-

Valves are delivered incl. insulation caps

RA 2000 product range

Type	Code no.	Design
RA-N 10	013G0011	Angle
RA-N 10	013G0012	Straight
RA-N 10	013G0151	Reverse angle
RA-N 10	013G0231	Right mounted
RA-N 10	013G0232	Left mounted
RA-N 15	013G0013	Angle
RA-N 15	013G0014	Straight
RA-N 15	013G0153	Reverse angle
RA-N 15	013G0233	Right mounted
RA-N 15	013G0234	Left mounted
RA-N 20	013G0015	Angle
RA-N 20	013G0016	Straight
RA-N 20	013G0155	Reverse angle

Type	Code no.	Design
RA-U 10	013G3231	Angle
RA-U 10	013G3232	Straight
RA-U 15	013G3233	Angle
RA-U 15	013G3234	Straight

Type	Code no.	Description
RA 2990	013G2990	5-26°C built in sensor
RA 2992	013G2992	5-26°C remote sensor Capillary tube 0-2 meter
RA 2920	013G2920	5-26°C built in sensor, tamper proof
RA 2922	013G2922	5-26°C remote sensor, tamper proof Capillary tube 0-2 meter

Notes

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On our website you can find:

Literature
Both commercial as 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 ASV whiteboard animation

This animation shows how automatic balancing valves can be a great solution to improve the performance of your heating system and reduce costs at the same time.

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