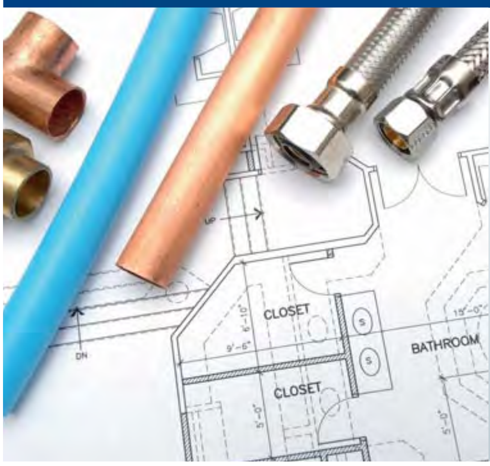
VORTEX HIGH EFFICIENCY
DOMESTIC HOT WATER PUMPS

TECHNICAL GUIDE

DOMESTIC HOT WATER CIRCULATION WITH VORTEX PUMPS



General information on DHW circulation systems
VORTEX DHW circulation pumps
Control components
Installation and maintenance
Sizing DHW circulation systems
Hygiene requirements

VORTEX

MADE IN GERMANY

VORTEX TECHNICAL GUIDE

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VORTEX

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LIST OF ABBREVIATIONS

TERMINOLOGY

D	Butterfly valve
DHW	Domestic Hot Water
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DN	Nominal diameter
DVGW	Deutsche Vereinigung des Gas- und Wasserfaches (German Technical and Scientific Association for Gas and Water)
EDV	Electronic data processing
EN	European standard
EnEG	Energy Saving Act [Germany]
EnEV	Energy Saving Ordinance [Germany]
ISO	International standard
TrinkwV	Drinking Water Ordinance [Germany]
TS	Partial section
TW	Domestic water (potable water)
TWE	Domestic water heater (DHW heater)
TWW	Domestic hot water
TWZ	DHW circulation
ZR	Circulation control valve

FORMULA SYMBOLS

c	Specific thermal capacity of water	[Wh/kg K]
d_a	External diameter	[mm]
H	Delivery head	[m]
l	Length (of a partial section)	[m]
$l_{w,K}$	Length of all supply lines required for circulation in the basement/cellar	[m]
$l_{w,S}$	Length of all supply lines required for circulation in the shaft	[m]
p	Pressure	[bar]
Δp_D	Excess pressure to be reduced	[mbar]
Δp_p	Manometric pressure of the circulation pump	[mbar]
Δp_{TH}	Pressure drop of thermostatic valve (where provided)	[mbar]
Δp_{AP}	Pressure drop in equipment (e.g. external heat exchanger to cover the heat loss in the DHW circulation system)	[mbar]
Δp_{RV}	Pressure drop of the non-return valve as per manufacturer's data	[mbar]
$\dot{Q}_a$	Heat loss from hot water pipes in the branch-off	[W]
$\dot{Q}_d$	Heat loss from hot water pipes in the straight-through line	[W]
$\dot{Q}_w$	Heat loss from all hot water pipes	[W]
$\dot{q}_{w,K}$	Heat loss from all hot water pipes in basement/cellar	[W/m]
$\dot{q}_{w,S}$	Heat loss from all hot water pipes in shaft	[W/m]
R	Pipe friction pressure drop	[mbar/m]
T	Temperature	[°C]
t	Time	[h]
$\dot{V}$	Flow rate directed to the branch	[m³/h]
$\dot{V}_P$	Pump rate of DHW circulation pump	[m³/h, l/h]
$\dot{V}_a$	Flow rate in the diverging section	[m³/h]
$\dot{V}_d$	Flow rate in the straight-through line	[m³/h]
$\dot{V}_Z$	Circulation flowrate in an individual section	[l/h]
$\dot{V}_{RL}$	Water content in the DHW circulation system	[m³]
v	Flow speed	[m/s]
Z	Pressure drop from individual resistances	[mbar]
ρ	Water density	[kg/l]
$\Delta\vartheta$	Temperature differential	[K]
$\Delta\vartheta_w$	Calculated temperature differential and/or cooling of the hot water up to the the point where the circulation line branches off from the supply line	[K]
ζ	Loss factor	
[ ]	Reference to source note in list of sources, see page 26	

1. GENERAL CRITERIA FOR THE USE OF DHW CIRCULATION SYSTEMS

1.1 REQUIREMENTS REGARDING WATER QUALITY AND DHW CIRCULATION SYSTEMS

Drinking water is water which conforms to the DIN 2000 standard in terms of its appearance, smell and taste, as well as chemical, physical and bacterial properties.

The key requirement regarding water quality is set out in paragraph 4 of the current Drinking Water Ordinance (TrinkwV) [Germany] [1, 2]: The water must be pure, fit for consumption and pathogen-free in particular. This requirement is regarded as being met if concentrations of microorganisms and chemical substances are below certain limits. Ensuring the basic quality of drinking water is chiefly the remit of water supply companies. The technical guidelines for protecting potable water and maintaining its quality in a DHW installation are specified in DIN 1988-100 [4], and elsewhere. Drinking water remains drinking water until it is drawn by the user. This also applies to the hot water being circulated, both in the hot water distribution system and the DHW circulation lines. Specific technical measures are therefore required to guarantee the quality of drinking water until it is drawn from the system.

1.2 GENERAL INFORMATION ON THE USE OF DHW CIRCULATION SYSTEMS

In systems with centralised DHW heating, greater pipe lengths require a DHW circulation line, to ensure that the hot water is available at the tapping point at the required temperature. Circulation within the system is achieved with the help of a DHW circulation pump.

Natural circulation (gravity circulation), if in fact physically possible, is no longer considered viable due to the high energy use associated with it. Technical regulations concerning DHW installations therefore exclude this option. It is now mandatory to install DHW circulation systems even in small residential units (one/two-family houses) if the volume of water in the supply line from DHW heater to furthest tapping point exceeds 3 litres [5].

The time and duration of the pump's operation can be controlled via various control components. This prevents the pump from running continuously (see also chapter 3).

1.3 BASIC STRUCTURE OF A DHW DISTRIBUTION SYSTEM WITH CIRCULATION

A DHW circulation system consists of a supply line (flow) and the DHW circulation line (return). The supply line extends from the DHW heater up to the last tapping point. The circulation line starts below the supply line's highest branch piece. Pipe runs with circulation can be installed with lower **(Fig. 1)** or upper distribution **(Fig. 2)**.

Regulating valves must be installed in the individual circulation lines (hydraulic balancing). These prevent large flows from being circulated in sections where the flow is easier, while others remain largely "dead" and therefore cold (see also chapter 3.6).

Provide a non-return valve in the DHW circulation line downstream of the pump. This is to avoid gravity circulation as well as flow through the DHW circulation pump to tapping points against the direction of flow. A non-return valve is already integrated as standard in the V pump housing of VORTEX DHW circulation pumps with spherical motor.

The DHW circulation pump is installed in the circulation line, with the direction of flow to the DHW heater **(Fig. 3)**.

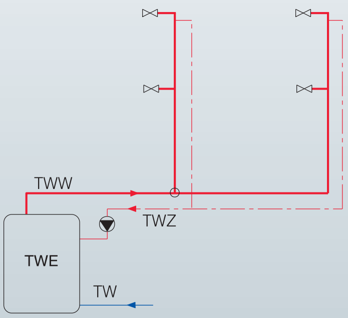

Fig. 1: Lower distribution

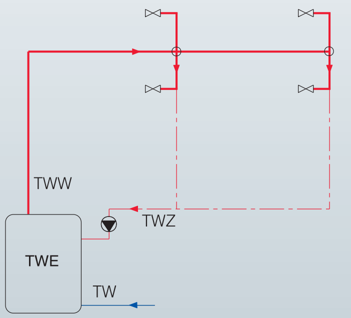

Fig. 2: Upper distribution

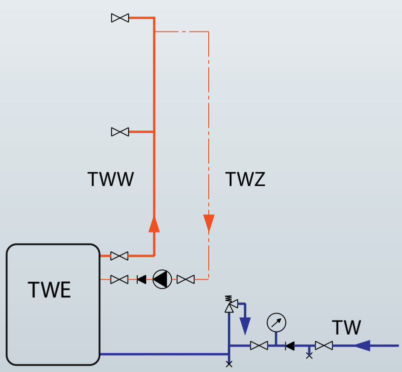

Fig. 3: Structure of a DHW distribution system with circulation

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1.4 CONDITIONS FOR ECONOMICAL USE OF A DHW CIRCULATION SYSTEM

Specific measures should be introduced to reduce the amount of energy used when operating the DHW circulation pump.

MEASURES TO REDUCE ENERGY CONSUMPTION:

- Size DHW circulation pump as small as possible
- Correctly size supply lines and DHW circulation lines
- Thermal and/or timed control of DHW circulation pump (see chapters 3.1 to 3.3)
- Control via circulation control valves (see chapter 3.6)
- Insulate supply lines and DHW circulation lines in accordance with EnEV

1.5 TECHNICAL GUIDELINES ON THE SIZING OF DHW CIRCULATION SYSTEMS

1.5.1 DIN 1988 CODES OF PRACTICE FOR DRINKING WATER INSTALLATIONS

This standard (part 200 for closed systems) [5] comprises rules for planning, installing, modifying, maintaining and operating DHW installations in buildings and on plots of land. Part 300 [6] specifies the criteria for sizing DHW circulation systems.

When sizing the DHW circulation pump, ensure the flow speed in the circulation line does not exceed 0.5 m/s. In DHW circulation systems with several circulation lines, it is mandatory to install control fittings (regulating valves) for hydraulic balancing.

1.5.2 ENERGY SAVING ORDINANCE (ENEV)

The Energy Saving Ordinance (EnEV) [3] is based on the German Energy Saving Act (EnEG), which aims to ensure that no more than the necessary amount of energy is consumed in buildings. Preventing energy from being wasted in this way is intended to combat climate change.

The EnEV (Energy Saving Ordinance on thermal insulation and energy-saving installations in buildings) came into force on 1 February 2002 and was last amended on 1 May 2014. The key provisions stated are as follows: Pipes and fittings/valves in a hot water system must be insulated with the specified minimum insulation thickness to prevent heat losses. The DHW temperature in the pipework must be limited to a maximum of 60 °C. The DHW circulation pump must be equipped with a self-actuating start/stop mechanism to prevent it running continuously.

1.5.3 DVGW CODES OF PRACTICE W 551 AND W 553

DVGW Code of Practice W 551 [8] describes technical measures for reducing the growth of legionella bacteria in DHW systems. The key requirements are as follows:

- Maintain a minimum hot water outlet temperature at the DHW heater of 60 °C, or 50 °C in small installations (higher temperatures would be more effective in destroying legionella, but would result in greater energy losses, as well as increased limescale deposits and material wear).
- The temperature drop in the circulating DHW system must be no more than 5 K.
- Set time controls in a way that the circulation is not interrupted for more than 8 hours per day (under certain conditions pump runtimes may be reduced further (see chapter 6.3)).
- Design the system in a way that all water in the pre-heat stages can be heated up to 60 °C once per day.
- Single-floor and individual supply lines with water volumes of up to 3 litres can be engineered without circulation.
- Systems with water volumes above 3 litres between the heater and tapping point, as well as large installations, must be fitted with DHW circulation lines (see chapter 1.2).

Due to the high temperatures in the DHW system, we recommend installing fittings with an integrated temperature limiter or thermostatic mixer taps to prevent scalding. The Code of Practice also describes remedial measures for DHW systems contaminated with legionella.

The sizing of DHW circulation systems in central DHW heating systems is described in DVGW Code of Practice W 553 [9], which complements DIN 1988 Part 300 (see chapter 5.6). The calculation method described in this Code of Practice requires that the supply lines and DHW circulation lines are insulated in accordance with the EnEV.

2. VORTEX DHW CIRCULATION PUMPS

Energy saving and user convenience are the primary aims of VORTEX DHW circulation pumps. The highly efficient permanent magnet motor in the latest **BlueOne** pump series (type BWO 155) is primarily suitable for detached houses and small apartment buildings and has a very low power consumption of 2.5 to 9 watts. VORTEX control components and accessories satisfy the EnEV requirements for self-actuated starting/stopping of the DHW circulation pump and for DHW temperature limiting.
The modular structure of the **BlueOne** series enables various combinations of pump housing, motor and control components to suit each individual application:

Fig. 4: BWO 155 SL
Self-learning module with **AUTO***learn* technology

Fig. 5: BWO 155 Z
Time switch

Fig. 6: BWO 155 ERT
Electronic control thermostat

Fig. 7: BWO 155
Without control module

The full range of pumps and further information are available online at **www.deutsche-vortex.de** or can be sent to you on request.

2.1 TECHNICAL INFORMATION

Like the previous VORTEX BW 150–154 pump series, VORTEX DHW circulation pumps in the **BlueOne** series are fitted with a spherical motor.

Unlike the conventional canned motor, the spherical motor does not feature a revolving bearing shaft. Instead it has a fixed bearing pin with a semispherical rotor above. The stator generates a rotating magnetic field and transfers this to the rotor located in the water-carrying part of the pump. The water-carrying part of the pump is hermetically separated from the stator.

SPECIFICATION

Electr. connection	1~115–230 V / 50–60 Hz or 12 V=
Speed range	2000–3000 rpm
Power consumption 115–230 V ~ (12 V =)	2.5–9 W (2–7 W)
Pressure resistance	10 bar
Temperature resistance	95 °C
Max. pump rate	950 l/h
Max. delivery head	1.3 mWS

DESIGN

The rotor and its bearing cup rest on a bearing ball, which is permanently linked to the separating cap via the bearing pin **(Figs. 8, 9)**. One benefit of this design is the zero-play bearing, which, having only one bearing point, generates very low friction. This helps to keep the power consumption of the spherical motor very low and results in minimal noise emission. The rotor bearing is self-adjusting and lubricated by the water.
VORTEX **BlueOne** circulation pumps are ideally combined with the V-type housing (screw fitting), in which the ball shut-off valve and non-return valve are already integrated. If combined with the R-type pump housing, these components must be retrofitted.

The motor can be detached from the pump housing. This enables easy removal and refitting of the motor for maintenance purposes.

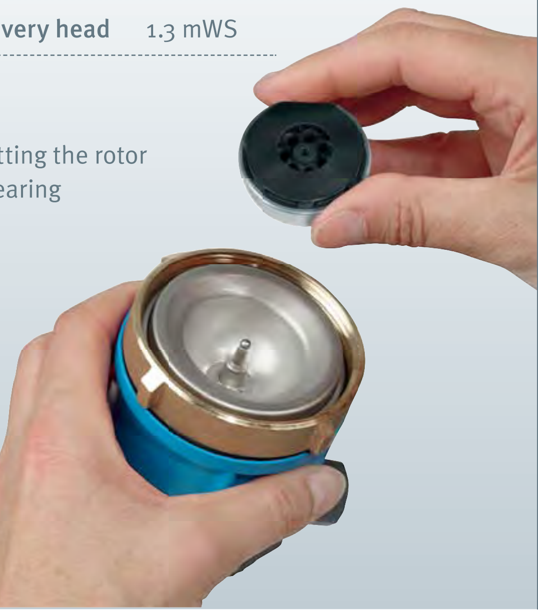

Fig. 8: Fitting the rotor on the bearing

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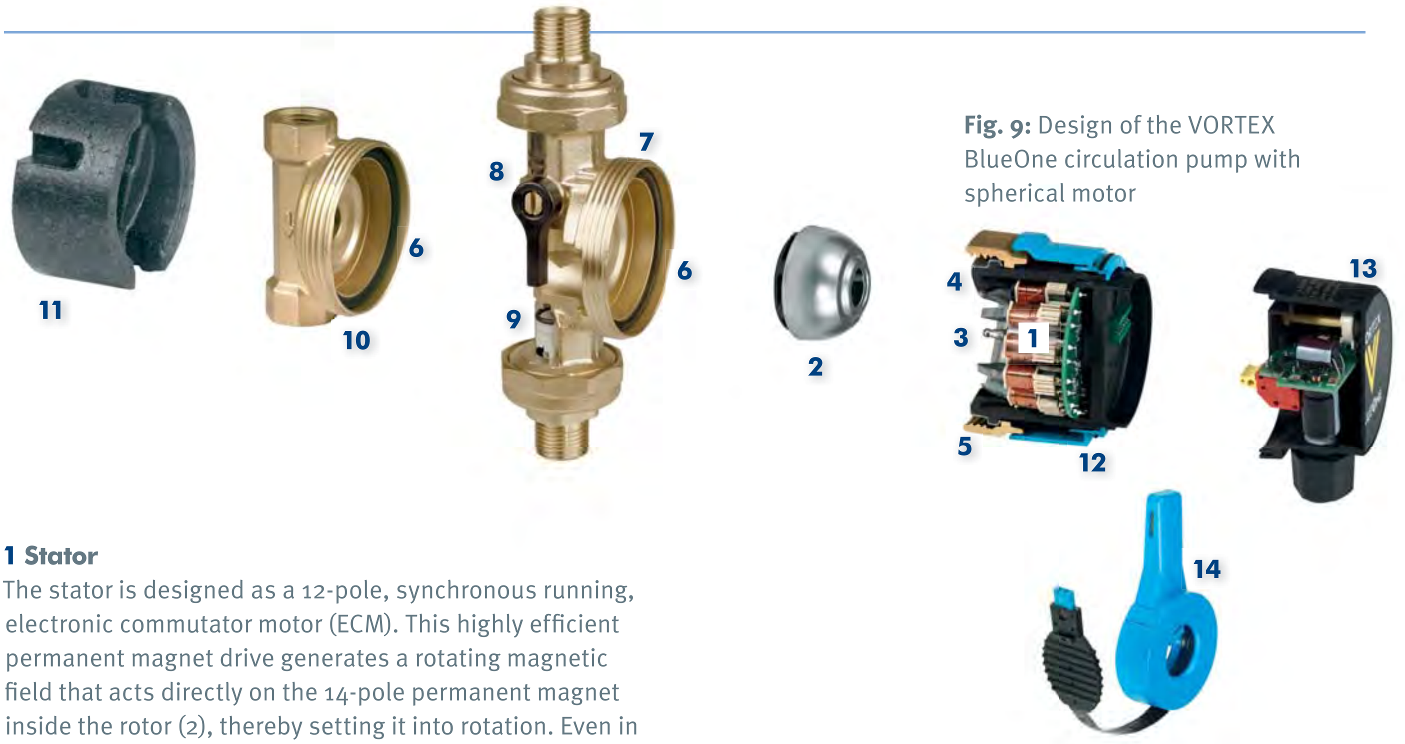

Fig. 9: Design of the VORTEX BlueOne circulation pump with spherical motor

1 Stator

The stator is designed as a 12-pole, synchronous running, electronic commutator motor (ECM). This highly efficient permanent magnet drive generates a rotating magnetic field that acts directly on the 14-pole permanent magnet inside the rotor (2), thereby setting it into rotation. Even in idle state the magnetic field is highly effective. The axial components exude a pulling force on the rotor, which is thereby stabilised in its longitudinal axis.

2 Rotor

With its bearing cup made from high quality bearing material, the rotor is held in a gyrating (cardanic) position on the bearing ball (3). This bearing principle has the following key benefits:

- ✔ There is only one bearing (conventional pumps require two cylinder bearings for holding the drive shaft in place).
- ✔ The bearing pair works with zero play. Generated by the stator, the axial magnetic force that acts on the rotor enables the bearing cup of the rotor to run on the ball with zero play, even when the bearing is worn. This prevents the ingress of foreign particles and guarantees a long service life for the pump.
- ✔ The bearing friction is very low. The special shape of the bearing components and the small bearing diameter are key reasons for the spherical motor's low power draw. The bearing breakaway following extended idle time that is necessary on motors with a cylinder bearing is not required with the spherical motor.

3 Bearing pin and ball

The stainless steel bearing pin is homogeneously welded to the separating cap (4). The ball is made of hard-wearing and corrosion-resistant material and firmly linked to the bearing pin.

4 Separating cap

Made of stainless steel, the cap hermetically separates the water-carrying part from the live part of the motor without an additional seal.

5 The union nut

The union nut guarantees a secure connection between the motor and the pump housing. This type of fitting evenly pushes the sealing ring (6) on to the entire sealing surface. The motor can easily be removed and refitted for maintenance purposes.

6 Sealing ring

Due to its construction, the VORTEX DHW circulation pump requires only one sealing ring between the spherical motor and the pump housing. The sealing ring material is hydrolysis- and age-resistant. This ensures the DHW circulation pump is leak-proof throughout its service life.

7 V-type pump housing

The internal profile of the pump housing is designed to achieve a high level of hydraulic efficiency in the transfer of the energy emitted by the pump impeller.
The housing is equipped with a non-return valve and ball shut-off valve as standard. Union fittings enable direct connection to all pipe dimensions. The fittings, optionally available as 1/2", 3/4", Ø 15 or Ø 22, for screwing, soldering or pressing are included.

8 Ball shut-off valve
The ball shut -off valve is already installed in the V-type pump housing. In the event of maintenance work, the suction side can be isolated from the pipework.

9 Non-return valve
The non-return valve is also already installed in the V pump housing. It is spring-loaded and therefore also acts as a "gravity brake" (preventing gravity circulation). In the event of maintenance work it automatically seals off the pressure side (to the DHW heater).

10 R 1/2" pump housing
The VORTEX DHW circulation pump can also be fitted with a pump housing with R 1/2" female thread. In this case, the ball shut-off valve and non-return valve are not integrated and must be fitted separately.

11 Insulating shell
The insulating shell prevents excessive cooling of the pump housing and the associated heat loss.

12 Temperature sensor
The temperature sensor (not shown in the figure) is used to thermally control the circulation flow. The sensor is a switch element located on the motor PCB.

13 Connection cap or control component
In place of the connection cap without control unit, a time switch, thermostatic module or self-learning module may also be fitted. These control components serve to minimise pump runtimes (see chapter 3).

14 Cable box
The cable box is used in conjunction with the self-learning module. It contains a 2.5 m long ribbon cable and the temperature contact sensor for the flow line.

2.2 WARRANTY
Extremely accurate production using the latest manufacturing methods, strict quality checks and the use of high quality materials enable a 3 year warranty from the date of manufacture to be issued with VORTEX DHW circulation pumps (for pump with BWO 155 SL self-learning module: 5 years).

The quality management system of
Deutsche Vortex GmbH & Co. KG
is certified to DIN EN ISO 9001:2008.

2.3 MAINTENANCE
DHW circulation pumps are at greater risk from corrosion than from excessive thermal load. Limescale deposits from the hot water enlarge this factor. The scaling may cause moving parts to malfunction.

The severity of scaling increases with the temperature of the hot water. For this reason the DHW temperature must not exceed 60 °C. Limescale starts to be deposited at temperatures below 40 °C. In areas with hard water it is therefore recommended to descale and clean the DHW circulation pump at suitable intervals **(Fig. 10)**.

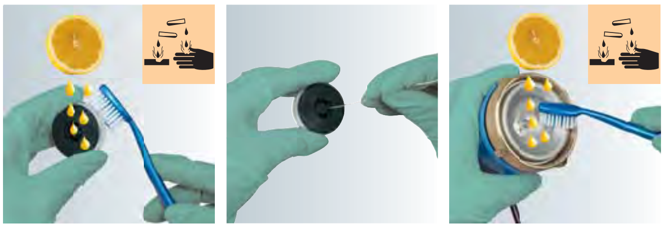

Fig. 10: Cleaning the rotor and separating cap

VORTEX DHW circulation pumps with spherical motor are exceptionally easy to service. The shaftless spherical motor facilitates maintenance, unlike pumps with a revolving motor shaft and friction bearing. For this reason, VORTEX pumps are not subject to any water hardness limits.

The motor is attached to the pump housing by a union nut, which allows quick and easy removal and refitting:
- ✔ Disconnect pump from power supply
- ✔ Close ball shut-off valve
- ✔ Undo union nut and remove motor
- ✔ Clean DHW circulation pump

The pump housing remains in place inside the pipework. Please refer to the installation and operating instructions for information on maintenance procedures.

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3. CONTROL COMPONENTS FOR DHW CIRCULATION PUMPS

According to the EnEV, DHW circulation pumps must be fitted with a control component that prevents continuous operation (see chapter 1.5.2). A maximum runtime of 16 h per day is recommended (see chapter 1.5.3). The aim of the control function is to save energy and minimise pump runtimes. This also limits limescale deposits.

3.1 TIME SWITCH

A time switch is a popular control component for DHW circulation pumps. The times at which DHW is provided depend on the type of use for the building and are therefore set individually at the time switch.

3.2 THERMOSTAT

A thermostat thermally controls the circulation. As DHW flows through the circulation pump, the thermostat switches the pump off when the chosen temperature limit has been reached. If the water cools to below a certain temperature, the thermostat switches the pump back on.

The thermostat may be used as an independent control component or combined with an external interval timer (external control or time switch). When combined with an interval timer, the thermostat performs thermal control in addition to the time control.

3.3 SELF-LEARNING MODULE

Whereas time switch settings are based on estimates and assumptions regarding user behaviour, the self-learning module featuring **AUTO***learn* technology automatically detects usage habits. The times that DHW is tapped are quickly learnt without any action on the user's part, and DHW is made available accordingly.

The PCB detects deviations from the normal routine, such as weekends, absences or clock changes, and adjusts the pump's running characteristics to suit. When absences are detected, the pump performs regular purges to ensure that the water in the DHW circulation system is replaced regularly. Likewise, thermal disinfection by the DHW heater is detected automatically. Simultaneous pump operation then ensures that the whole circuit is disinfected (see also chapter 6.3).

3.4 CONNECTION BETWEEN ENERGY CONSUMPTION AND RUNTIME

There is a linear correlation between the amount of energy required to provide DHW and the pump runtime. The savings achieved in the examples depend on factors such as the type of installation, the set shutdown temperature and the comfort level selected.

Fig. 11: If the circulation pump is operated continuously, the energy costs associated with provision of DHW equal 100 %.

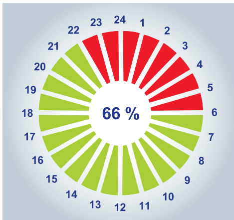

Fig. 12: Switching the circulation pump off for eight hours during the night by means of a time switch reduces the operating time by a third. This reduces energy costs by the same amount, to 66 %.

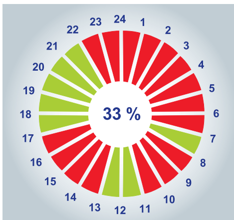

Fig. 13: If the time switch additionally shuts down the pump during specific daytime hours, the circulation pump runtime can be limited to eight hours. This results in a two-third reduction in energy costs to 33 %.

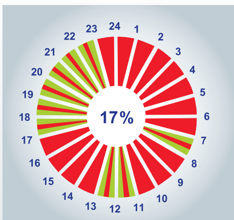

Fig. 14: If the circulation pump is also switched off by a thermostat during the eight-hour runtime, the energy costs can be reduced to around 17 %.

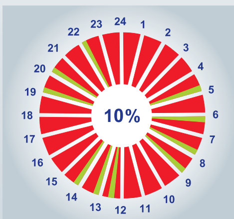

Fig. 15: Energy costs are further reduced to around 10 % if a circulation pump with self-learning module is used. The self-learning module continuously optimises itself, thereby achieving minimal pump runtimes.

Pump running
Pump not running

3.5 PAYBACK PERIOD

Using control components can reduce pump runtimes considerably, as opposed to continuously running a DHW pump. Reducing the runtime saves energy in two ways: By reducing the power consumption and more significantly by reducing the amount of heat loss associated with a running pump. **Fig. 16** provides some examples of typical behaviour patterns based on a detached house with up-to-date installations (holidays, weekends, etc. are taken into account).

Optimum savings combined with maximum comfort are achieved with the VORTEX **BlueOne** BWO 155 SL high efficiency circulation pump with self-learning module, which adjusts automatically to user behaviour. The additional investment required is repaid in approx. 18 to 24 months, depending on which control variant was previously used **(Fig. 17)**. The example is based on the following costs: €0.25/kWh for electricity, €0.06/kWh for heating.

3.6 CIRCULATION CONTROL VALVE

The circulation control valve is a valve which opens or closes when the temperature in the DHW circulation system changes. It is controlled by a thermostat. The shutdown temperature of the thermostat can be selected.

Fitting circulation control valves saves energy and maintains the temperature stratification in the DHW heater.
In the case of branched circuits with varying circulation resistances, fitting a circulation control valve in each circuit enables specific control without having to install several or larger DHW circulation pumps. Circulation control valves are fitted in the individual DHW circulation lines **(Fig. 18)** or into a distributor directly upstream of the DHW circulation pump.

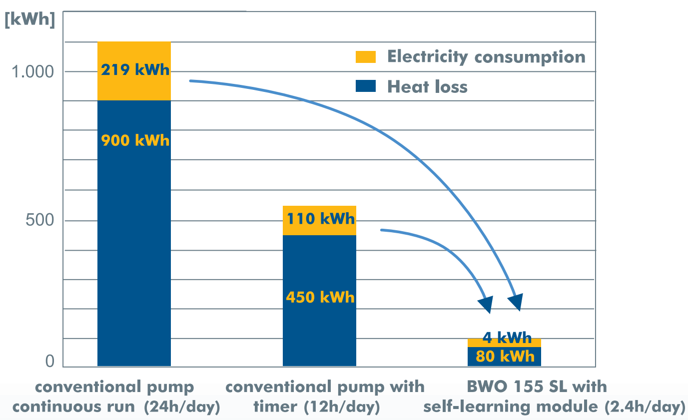

Fig. 16: Annual energy losses with typical pump controls

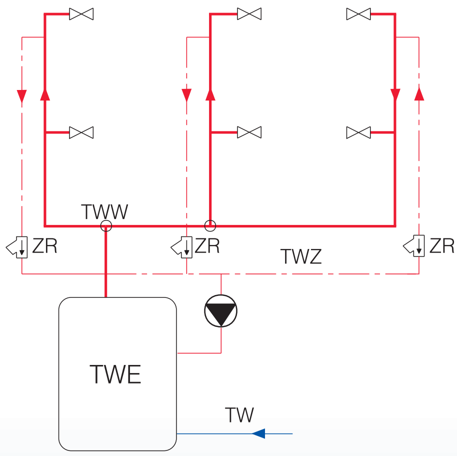

Fig. 18: Circulation control valves fitted in individual lines

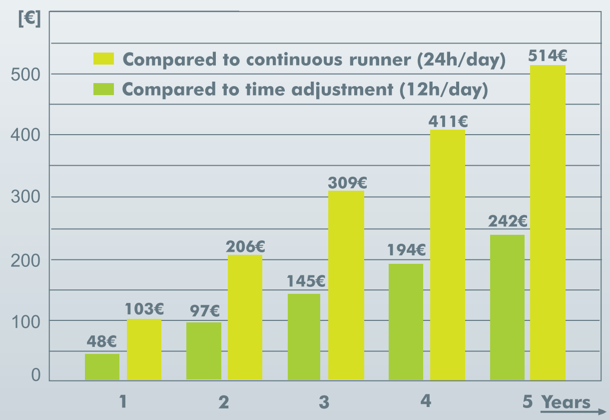

Fig. 17: Cost savings when installing the BWO 155 SL circulation pump with self-learning module compared to conventional pumps

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4. INSTALLING THE DHW CIRCULATION PUMP

4.1 GENERAL INFORMATION ON INSTALLATION

VORTEX DHW circulation pumps are installed into the DHW circulation line (return flow) **(Fig. 19 and 20)**.

Installing these pumps into the supply line (flow), which is the norm for heating pumps, has serious drawbacks:

- In the case of a DHW circulation pump with thermal control, the thermostat switches off the pump before the DHW reaches the tapping point.
- The DHW temperature is higher in the supply line than in the circulation line, which leads to increased limescale deposits.
- If DHW is drawn when the motor is switched off, water is forced through the rotor (turbine principle). This may damage the rotor bearing, due to magnetic stabilisation forces being lower than when the pump is running.

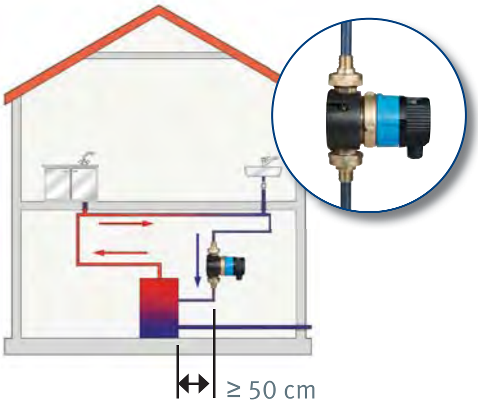


Fig. 19: Installing a VORTEX DHW circulation pump with V-type pump housing

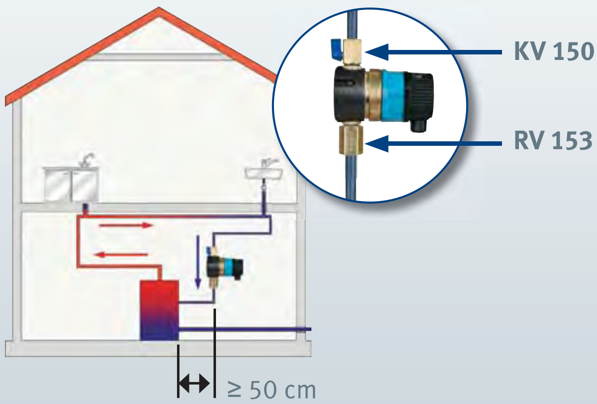


Fig. 20: Installing a VORTEX DHW circulation pump with R-type pump housing and additional non-return valve (RV 153) and shut-off device (KV 150)

The VORTEX DHW circulation pump must be installed in the permitted positions **(Fig. 21)**.

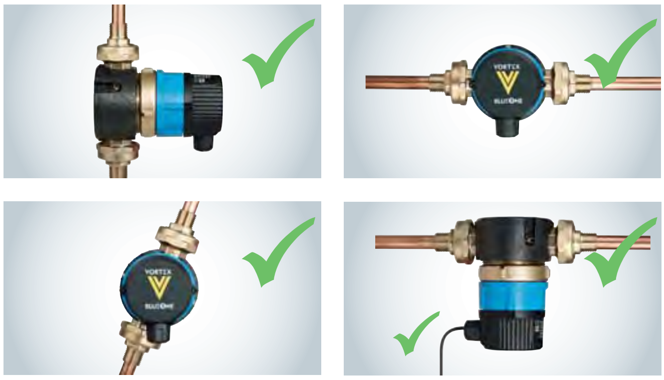


Fig. 21: Installation positions for VORTEX DHW circulation pumps

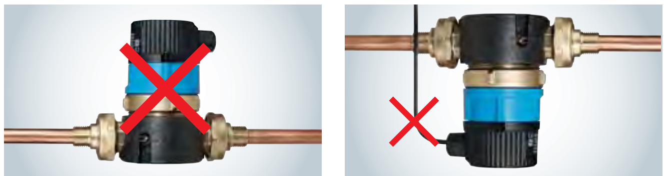


Fig. 22: Impermissible installation positions for VORTEX DHW circulation pumps

In the case of temperature-controlled DHW circulation pumps, take care not to install the pump too near to the DHW heater. The heat transfer from the DHW heater via the pipes can impair the thermostat function and/or temperature capture by the sensor.

4.2 VENTING THE DHW CIRCULATION SYSTEM

Before the VORTEX DHW circulation pump can be installed and operated, the DHW circulation system must be vented and purged. Failure to do so can cause bearing damage due to the pump running dry, or rotor damage as a result of installation residues or contamination. This will result in a significantly shorter service life for the DHW circulation pump.

"Venting" the circulation line via the tap fittings or by undoing the fittings on the circulation pump is not sufficient to prevent the circulation pump from running dry. Opening a tap fitting does not result in a flow in the DHW circulation line, as the integral non-return valve prevents this.

Air bubbles are purged from the supply line, but remain where they are in the horizontal section of the DHW circulation line or rise within the vertical section until they meet the next pipe bend.

Because high flow velocities are required to purge air bubbles and vent the system, opening the screw fittings at the circulation pump is also not sufficient. If correctly sized, the DHW circulation pump is too weak to vent the entire DHW circulation system, as the generated flow velocity is far too low. Air bubbles therefore take a long time to migrate to the circulation pump, where they remain and cause dry running.

The VORTEX venting flange is ideal for venting DHW circulation pumps with spherical motor. The venting flange is simply fitted to the pump housing in place of the motor. A discharge hose is placed over the hose connector and the DHW circulation system can then be vented by opening the ball valve **(Fig. 23)**. The 1/2" cross-section of the outlet

Fig. 23: Venting with the VORTEX EF 150 venting flange

produces a high flow velocity in the DHW circulation line, which forces out any existing air.

The air remaining in the pump housing after the motor is refitted dissipates relatively quickly after the circulation pump is switched on.

In branched DHW circulation systems, individual lines can be selectively vented by blocking off the other lines. To do this, each individual line must be fitted with a shut-off device. If using a thermostatic line regulating valve, which depending on the make can replace the shut-off device, note that the system is vented when cold.

4.3 REPLACING THE MOTOR RATHER THAN THE PUMP

When it becomes necessary to replace the pump (when it reaches the end of its service life, for example), the expense can be reduced by simply replacing the pump motor rather than the entire pump including housing. This is only possible if the existing pump housing is still intact (no excessive limescale deposits, no corrosion, functioning non-return valve in/on the pump housing).

The VORTEX rotor is designed so that **BlueOne** pump motors can be fitted to all common brass pump housings on the market, regardless of the year of manufacture **(Fig. 24)**. This places no restrictions on pump rate or running characteristics.

Fig. 24: Compatibility of VORTEX BlueOne pump motors with all brass pump housings

The VORTEX strap wrench **(Fig. 25)** is particularly suitable for loosening and refitting the pump motor. The flexible strap is almost entirely in contact with the brass union nut, allowing high levels of torque to be applied without damaging the union nut.

Fig. 25: VORTEX strap wrench for loosening and fitting the pump motor

4.4 NON-RETURN VALVE

Each DHW circulation system must be fitted with a non-return valve, also referred to as a reflux inhibitor. DHW circulation systems without non-return valves are not functional. The DHW may only reach the tapping points via the supply line. This important aspect is ensured by the non-return valve.

If there is no non-return valve, DHW when being drawn can flow to the tapping points via the DHW circulation line and circulation pump.

A missing non-return valve may cause the following faults:

- A temperature-controlled DHW circulation pump switches off.
- Cold water flows through the circulation pump when the circulation line is connected to the cold water supply line (in the absence of a DHW circulation connection at the DHW heater). This causes condensation to form in the motor compartment, which can destroy the live part of the motor.
- The resulting gravity circulation renders the measures employed for energy-efficient control of the DHW circulation system (e.g. via time switch) ineffective.
- If DHW is drawn when the motor is switched off, water is forced through the rotor against the direction of flow. The rotor bearing is damaged due to the reduction in magnetic stabilisation forces.

VORTEX DHW circulation pumps with V-type pump housing are already fitted with non-return valves (see chapter 4.1). For VORTEX DHW circulation pumps with R-type pump housing, a VORTEX RV 153 non-return valve **(Fig. 26)** must be fitted at the pump outlet. Only this particular non-return valve is designed to handle the output of the VORTEX DHW circulation pump, whereas other makes may offer too much resistance.

Fig. 26: VORTEX RV 153 non-return valve

4.5 AVOIDING INCORRECT INSTALLATION

4.5.1 GENERAL INFORMATION ON FAULTS

VORTEX DHW circulation pumps operate safely and reliably. Despite careful manufacture and rigorous quality checks, a fault may occasionally occur. This cannot be avoided with mass-produced technology. Most complaints received, however, are not related to a manufacturing fault. Some important guidelines must be observed when installing DHW circulation pumps. Failure to observe these instructions may impair the function of the DHW circulation system and/or cause premature failure of the DHW circulation pump.

4.5.2 INSTALLATION ERRORS

Known installation errors and their consequences are:

- **Incorrect installation location or position**
  - **External temperature influence**
    If the DHW circulation pump is installed in the immediate vicinity of the DHW heater or other heat sources, heat transfer will affect the thermostat function.
  - **Incorrect installation position**
    Installing the DHW circulation pump with the motor axis pointing upwards (see chapter 4.1) can cause air bubbles to form in the rotor area, resulting in dry running. Additionally, the rotor is not adequately stabilised on the bearing pin when the pump is switched off.
  - **Incorrect installation location**
    The DHW circulation pump was installed in the supply line (see chapter 4.1).
  - **Incorrectly fitted temperature sensor**
    The cable box with integrated sensor (model BWO 155 SL with self-learning module) was not fitted on the supply line, not fitted on smooth pipe material or fitted at an incorrect distance from the boiler outlet **(Fig. 27)**. This means that the sensor is unable to detect the hot-water taps that the system should be learning (temperature changes are not detected).
- **Inadequate venting**
  Air bubbles present in the DHW circulation system are pulled along by the water flow. They can collect in the DHW circulation pump and cause dry running (see chapter 4.2).

- **Faulty line regulation**
  Varying pipework pressure drop values in a branched DHW circulation system mean that the longer circuits with a higher pressure drop are inadequately supplied and thus remain cold. The DHW flows to the circulation pump via the circuit with the lowest pressure drop. A DHW circulation pump with thermostat or self-learning module switches off too early. This creates the impression that the pump is not fulfilling its function.
  To ensure that all circuits are evenly supplied they must be hydraulically balanced using the correct line regulating valves (circulation control valves) (see chapter 3.6).
- **Missing non-return valve**
  The consequences of a missing non-return valve are described in chapter 4.4.
- **Faults in the electrical connection**
  - **Electrical connection to the boiler control**
    During "night setback" or other interruption to the operating time, there is zero volt at the time switch, which therefore loses the current time. The time switch runs slow or enters the setting mode. The self-learning module loses the learned tapping times when it is switched to zero volt.
  - **Electrical connection to the basement/cellar light**
    Making a direct connection to the mains in the distribution box has resulted in a connection to the cable that runs to the cellar light via the cellar light switch. The time switch and DHW circulation pump only run when the cellar light is on.

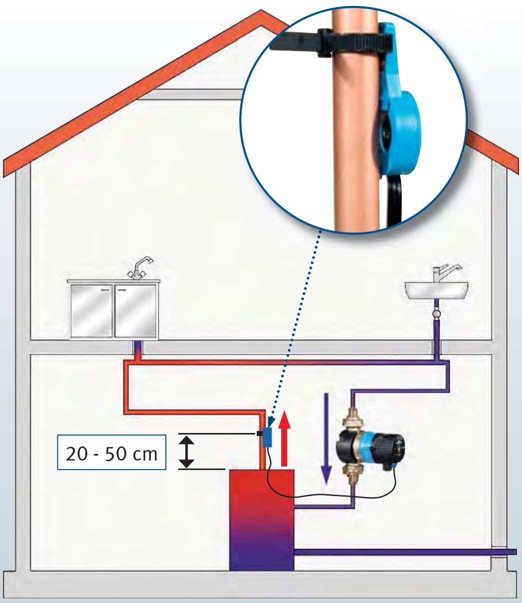


Fig. 27: Correct installation of a cable box with integral sensor (model BWO 155 SL)

4.5.3 CONTROL VIA THE BOILER

There are no significant differences as a result of controlling the DHW circulation pump via a separate control module or centrally via the boiler.
With central control, the DHW circulation pump is switched by the boiler control unit. Most heating boiler manufacturers provide a separate time channel controlled by an internal time switch for activating the DHW circulation pump. This eliminates the need for a time switch on the DHW circulation pump. In such cases we recommend using a VORTEX DHW circulation pump with thermostat. When using a self-learning module it makes little sense to control the system via the boiler. The self-learning module requires a permanent power supply (see "Faults in the electrical connection").

5. SIZING THE DHW CIRCULATION SYSTEM

5.1 PUMP CURVE

The hydraulic behaviour of the DHW circulation pump is described by its performance curve. This shows the relationship between delivery head and pump rate. The following relationship applies:

- As the pump rate increases, the delivery head decreases.
- As the delivery head increases, the pump rate decreases.

The pump rate is the throughput provided by the pump. The delivery head is the pressure differential achieved by the DHW circulation pump, converted to the height of a liquid column.

The pump curve is shown in a diagram.
The pump rate is plotted along the horizontal axis $\dot{V}_P$ and the delivery head along the vertical axis **(Fig. 28)**. The pump curve shows that the pump rate and delivery head are dependent on each other:

- At maximum delivery head H = 1.25 m the pump rate is $\dot{V}_P$ = 0.
- At delivery head H = 0.75 m the pump rate is $\dot{V}_P$ = 0.37 m³/h.
- At maximum pump rate $\dot{V}_{Pmax}$ = 0.64 m³/h the delivery head is H = 0.

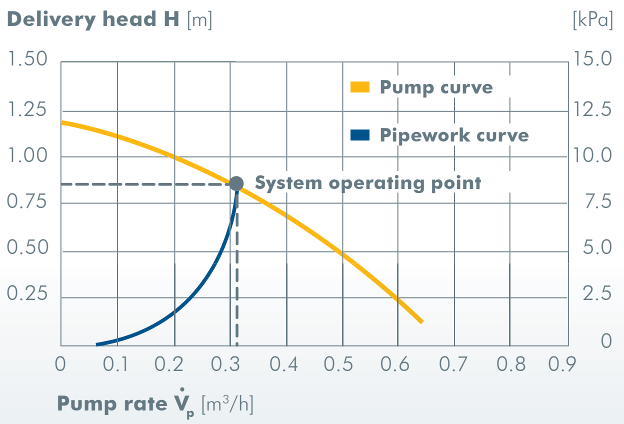


Fig. 28: Pipework and pump curve

5.2 PIPEWORK CURVE

The pipework performance curve is system-specific. It indicates the relationship between the pressure drop, caused by pipe friction and individual resistances, and the flow rate in the DHW circulation system. Unlike in the "open system" **(Fig. 29, 30 and 31)**, the DHW circulation pump does not have to overcome a height differential. This means that the delivery head indicated in the pump diagram has nothing to do with the height of the building in which the pump is to be installed.

A DHW circulation pump with a delivery head of 1.25 m can therefore operate extremely effectively in a 20 m tall building.

The "open system"
In an "open system", the correlation between pump rate and delivery head is immediately apparent. **Fig. 29, 30 and 31** relate to the pump curve in **Fig. 28**.
This theoretical example does not take into account any pipework pressure drop:

- If the pipe length, measured from the surface of the medium, corresponds to the maximum delivery head of the pump H_{max} = 1.25 m, no medium is discharged from the end of the pipe. The pump rate is thus $\dot{V}_P$ = 0 **(Fig. 29)**.
- If the pipe is shortened by 0.50 m, the DHW circulation pump must overcome a delivery head of H = 0.75 m. The volume discharged from the pipe end is equivalent to the pump rate $\dot{V}_P$ = 0.37 m³/h **(Fig. 30)**.
- If the pipe is shortened by 1.25 m, the pipe end is at the same level as the medium. The delivery head is therefore H = 0. The discharged volume is equivalent to the pump rate $\dot{V}_P$ = 0.64 m³/h **(Fig. 31)**.

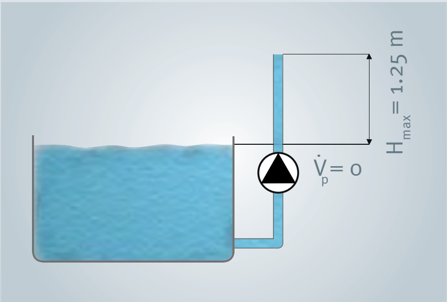


Fig. 29

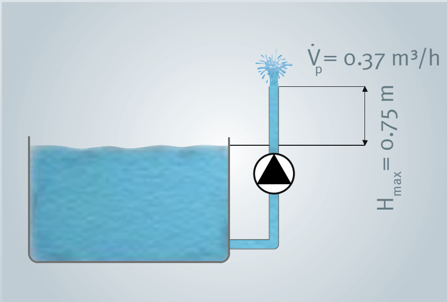


Fig. 30

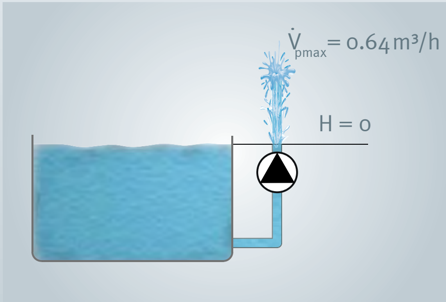


Fig. 31

5.3 OPERATING POINT

In the DHW circulation system, pressure drop and flow rate are directly dependent on each other. The pressure drop in the system, which must be converted into a pressure head drop, and the delivery head of the pump always reach a state of equilibrium. The pressure head drop in the system corresponds to the delivery head of the pump at the system operating point.

Because each pump delivery head is linked to one specific flow rate, the circulated throughput is entirely determined by the pressure drop in the system. The pressure drop is determined by projecting the pipework curve and the pump curve onto a common diagram **(Fig. 28)**. The intersection between the two curves indicates the resulting operating point of the DHW circulation system.

The operating point can be arithmetically determined by calculating the pressure losses from the individual resistances in the pipe network.

5.4 HYDRAULIC BALANCING OF DHW CIRCULATION LINES

In each of the system's DHW circulation lines, the pressure differential of the DHW circulation pump must be compensated for as much as possible using line regulating valves, while taking into account minimum diameters and maximum velocities.

If no hydraulic balancing is carried out, the calculated flow rates will not materialise in the system. However, the circulation throughput must be able to transport the amount of heat that is lost via the surface of the pipework system. The specified hot water temperature can only be maintained if an equilibrium is guaranteed at each point in the DHW circulation system. Hydraulic balancing of the DHW circulation system is therefore required in order to ensure a reliable function to DVGW Code of Practice W 551 [8].

In accordance with DVGW Code of Practice W 553 [9], line regulating valves must be installed in DHW circulation systems. The objective of the adjustment is to keep the circulation flow rates the same in all risers, in order to limit the temperature drop between the DHW heater outlet and re-entry via the circulation to approx 5 °C. It has been shown that in circuits near the pump, a relatively large pressure differential with small circulation flow rate must be created, while in pump risers further away from the pump, a proportionately large volume flow must occur to maintain a temperature in excess of 55 °C.

The following data is required for adjusting the line regulating valves in the DHW circulation system:

- ✔ Volume flow in that section
- ✔ Determined excess pressure loss via the line regulating valve
- ✔ Water temperature when hydraulically balanced

5.4.1 PRESETTING VIA MANUAL LINE REGULATING VALVES

The line regulating valves are sized and preset subject to the required valve data, the circulation throughput in that section and the required pressure drop via the valve. The required setting value can then be looked up in the manufacturer's diagram and set at the line regulating valve.

5.4.2 THERMOSTATICALLY CONTROLLED LINE REGULATING VALVES

Thermostatically controlled line regulating valves have been developed for the purpose of keeping the temperature in DHW systems above a set temperature. After the settings have been made on the thermostat and the control cross-section of the valve, the line regulating valve automatically assumes the required throttle positions. The valve must not close when the specified temperature is reached.

A condition for the use of such valves, which are a combination of conventional line regulating valves and thermal circulation control valves, is a pipe network calculation and a definition of the default setting value. Of particular advantage is the reduced need for adjustment at the building site, as minor deviations between the calculation and execution are automatically compensated for at the thermostatically controlled line regulating valve.

5.5 CALCULATION METHODS FOR DHW CIRCULATION SYSTEMS

DIN 1988 Part 300 [6] provides the basis for sizing supply lines and DHW circulation lines, as well as other system components. The standard came into effect in May 2012 as a Germany-wide supplement to DIN EN 806-3 [7].
DIN 1988-3 was withdrawn.

The regulations specified in DIN 1988-300 are based on the familiar and proven rules from the previous DIN 1988-3 standard and the DVGW Code of Practice W 553. They have been modified and adapted to take into account all recent findings. The calculation method described in DIN 1988-300 may in principle be carried out "by hand", but is so time-consuming that in practice the use of calculation software is strongly recommended (see chapter 5.7).
To nevertheless explain the principles for sizing DHW circulation systems, the calculation according to the currently applicable DVGW Code of Practice W 553 is shown below.

5.6 CALCULATION METHOD TO DVGW CODE OF PRACTICE W 553

Depending on the scale of the system, several methods are applied for sizing DHW circulation systems. All methods of calculation are based on generally accepted engineering standards. A particular requirement is that the DHW and circulation lines have been sized in accordance with EnEV specifications as a minimum.

5.6.1 SHORT PROCEDURE

This method is applied for smaller systems, such as those in detached and two-family homes. For these applications, a detailed calculation always produces the same dimensions for the DHW circulation system, primarily due to the nominal diameter graduation. The length of all DHW pipes required for circulation (excluding DHW circulation line) may not exceed 30 m and the longest flow path for a DHW circulation line (TWZ) should be no longer than 20 m **(Fig. 32)**.

If these conditions are satisfied, the DHW circulation lines is sized with a minimum internal diameter of DN 10 and the DHW circulation pump with DN 15.
If the DHW circulation line is created in copper pipe, proof is needed that the maximum permitted flow velocity will not exceed 0.5 m/s. The verification can be carried out using either the simplified or the differentiated calculation method.

5.6.2 SIMPLIFIED CALCULATION OF DHW CIRCULATION SYSTEMS

Applying the simplified calculation method for DHW circulation systems will result in a reduced level of accuracy. A positive aspect of this method is that it enables a relatively fast and simple calculation for small to medium-sized systems. Another advantage is that the temperature gradient can be freely chosen, the overall circulation flow can be precisely defined and the circulation flow can be split across the individual lines with adequate precision. Simplification is made possible by leaving aside the differentiated calculation of heat flux and the pressure losses due to individual resistances.

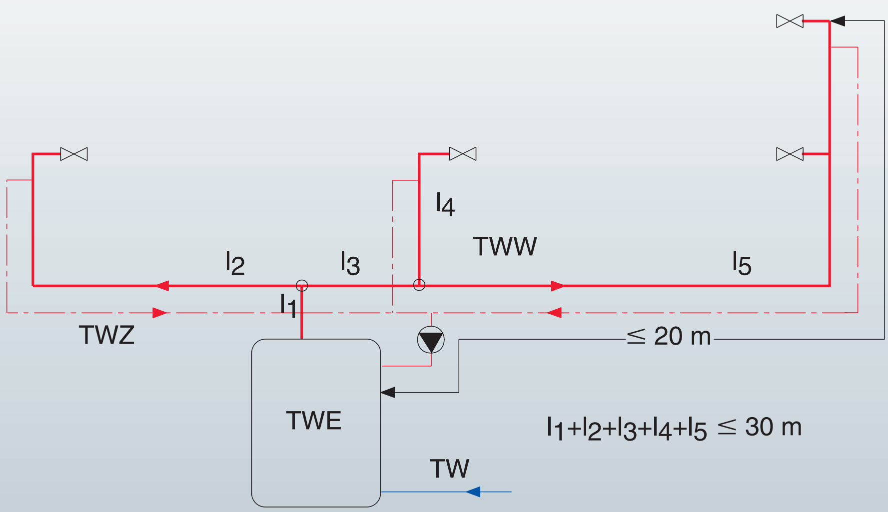


Fig. 32: Maximum permitted lengths for the short calculation

5.6.2.1 SIMPLIFICATION AND CALCULATION PROCEDURE

Determining volumetric flow

For the purpose of simplification, the following can be assumed when determining the heat losses in the DHW lines, which are required for defining the volumetric flow of individual sections:

- ✔ Heat loss of the DHW pipes in the cellar/basement: $\dot{q}_{w,K} = 11$ W/m
- ✔ Heat loss of the DHW pipes in the shaft: $\dot{q}_{w,S} = 7$ W/m

The heat losses of fittings are not taken into account, as they are insulated in accordance with the EnEV and are therefore negligible. The heat loss $\dot{Q}_w$ of all hot water pipes is therefore:

$$\dot{Q}_w = l_{w,K} \bullet \dot{q}_{w,K} + l_{w,S} \bullet \dot{q}_{w,S} \qquad (1)$$

The calculated temperature differential or cooling of the DHW on its journey to the point where the DHW circulation line branches off from the supply line is:

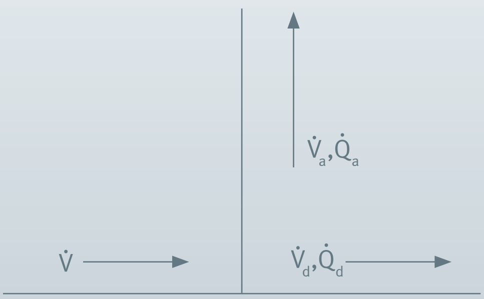
$$\Delta\vartheta_w = 2\,K$$

This temperature differential can then be used to determine the flow rate $\dot{V}_P$ [l/h] of the DHW circulation pump:

$$\dot{V}_P = \frac{\dot{Q}_w}{\rho \bullet c \bullet \Delta\vartheta_w} \qquad (2)$$

The following can be assumed:
$\rho = 1$ kg/l
$c = 1.2$ Wh/kg K

The DHW circulation flow rate obtained can be used to define the distribution of volumetric flow across the individual sections. At a branch point, the volumetric flow is split between a straight-through line and a branch-off.



The volumetric flow of the individual branch can be calculated as follows:

$$\dot{V}_a = \dot{V} \bullet \frac{\dot{Q}_a}{\dot{Q}_a + \dot{Q}_d} \qquad (3)$$

For the volumetric flow in the straight-through line, the following applies:

$$\dot{V}_d = \dot{V} \bullet \frac{\dot{Q}_d}{\dot{Q}_a + \dot{Q}_d} \qquad (4)$$

or

$$\dot{V}_d = \dot{V} - \dot{V}_a \qquad (5)$$

Sizing the pipe diameter for the DHW circulation line

The pipe diameters of the DHW circulation lines are determined taking into account a flow velocity of 0.2 to 0.5 m/s from R-value tables. A minimum internal diameter of 10 mm must however be provided. The individual DHW circulation lines are transferred to a suitable form and sized separately from the circulation mains.
It is possible that the flow velocity in lines near the pump is higher than in lines that are further away from the pump.

Determining the manometric pressure of the DHW circulation pump

The manometric pressure of the DHW circulation pump is determined using the frictional pressure drop of the most unfavourable circulation path. This is usually the longest circulation line with the greatest resistances. Diversions and side-branches are accounted by summarily adding 20 – 40 %.

This results in the following manometric pressure:

$$\Delta p_p = 1.2...1.4\ (\Sigma l \bullet R) + \Sigma\Delta p_{RV} + \Delta p_{TH} + \Delta p_{AP} \qquad (6)$$

The calculated pump rate and the manometric pressure can now be used to determine the actual operating point of the system and thus the actual operating point of the pump.

VORTEX

5.6.2.2 SAMPLE CALCULATION

To illustrate the calculation of larger DHW circulation systems, a sample calculation for an apartment building with 10 residential units is detailed below. In practice, the differentiated method according to DIN 1988-300 should be applied if the system size exceeds 6 residential units. This is because further important hydraulic factors need to be considered (see chapter 5.7).

- Apartment building with 10 apartments
- Pipe material: copper
- DHW pipes sized according to DVGW Code of Practice W 553
- Taps and fittings individually secured

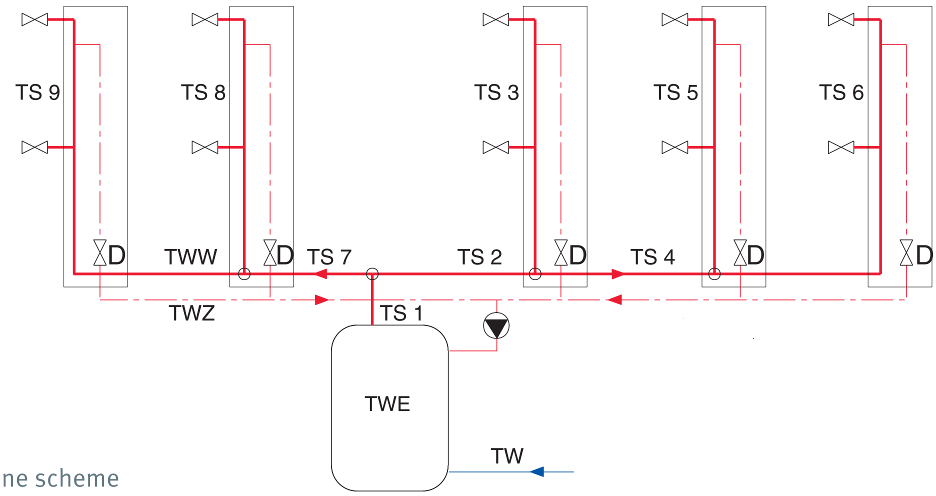


Fig. 33: Line scheme

Calculation of heat losses from partial flows in the DHW (TWW) sections according to equation (1)

SECTION	CELLAR/ SHAFT (K/S)	LENGTH l [m]	HEAT LOSS PER m $\dot{q}_w$ [W/m]	HEAT LOSS $l \cdot \dot{q}_w$ [W]	TOTAL $\Sigma l \cdot \dot{q}_w$ [W]
TS 1	K	3	11	33	33
TS 2	K	5	11	55	55
TS 3	S	12	7	84	84
TS 4	K	5	11	55	55
TS 5	S	12	7	84	84
TS 6	K	5	11	55	
	S	12	7	84	139
TS 7	K	5	11	55	55
TS 8	S	12	7	84	84
TS 9	K	5	11	55	
	S	12	7	84	139
	Sum of lengths	88		Sum of heat losses	728

Table 1: Heat losses from individual sections

Calculation of flow rates

The total heat losses from table 1 and the calculated temperature differential of $\Delta\vartheta_w = 2$ K can now be used to determine the pump rate for the DHW circulation pump according to equation (2):

$$\dot{V}_P = \frac{728 \text{ W}}{1 \text{ kg/l} \cdot 1.2 \text{ Wh/kgK} \cdot 2 \text{ K}} = 303.3 \text{ l/h}$$

The partial flows split at the branch points. The section which leads to the branch point in the direction of flow is shown in the first column of Table 2 (page 21).

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1 TWW SECTION TO BRANCH POINT	2 VOLUMETRIC FLOW TO BRANCH POINT $\dot{V}$ [l/h]	3 HEAT LOSS IN BRANCH $\dot{Q}_a$ [W]	4 HEAT LOSS IN STRAIGHT LINE $\dot{Q}_d$ [W]	5 HEAT LOSS IN BRANCH POINT $\dot{Q}_a + \dot{Q}_d$ [W]	6 VOLUMETRIC FLOW IN BRANCH $\dot{V}_a$ [l/h]	7 VOLUMETRIC FLOW IN STRAIGHT LINE $\dot{V}_d$ [l/h]	8 CHECK $\dot{V}_d = \dot{V} - \dot{V}_a$ [l/h]
TS 1	303	278[1)]	417[2)]	695	121	182	303–121
TS 2	182	84	278	362	42	140	182–42
TS 4	140	84	139	223	53	87	140–53
TS 7	121	84	139	223	46	75	121–46

Table 2: Calculation of partial flows in supply lines and DHW circulation lines

1) to the left in line scheme
2) to the right in line scheme

The first section is TS 1, which starts at the DHW heater (TWE). The flow rate in this section, which leads to branch point 1 in the direction of flow, is shown in column 2. This flow rate is split to the left into TS 7, which is defined as a branch, and to the right into TS 2, in this case the straight-through section. Heat losses from these two diverging sections are totalled individually. This means the heat loss in the branch (column 3) comprises the heat losses from sections 7 – 9:

$$\dot{Q}_a = (55 + 84 + 139)\ W = 278\ W$$

The heat loss from the straight line (column 4) is determined from the individual heat losses from sections 2 – 6:

$$\dot{Q}_d = (55 + 84 + 55 + 84 + 139)\ W = 417\ W$$

The heat loss in the branch point (column 5) is derived by adding together these two heat losses.

The individual flow rates in the branch (column 6) and in the straight line (column 7) can now be determined with equations (3) and (4):

in the branch to equation (3):

$$\dot{V}_a = 303\ l/h \bullet \frac{278\ W}{695\ W} = 121\ l/h$$

and in the straight line to equation (4):

$$\dot{V}_d = 303\ l/h \bullet \frac{417\ W}{695\ W} = 182\ l/h$$

In column 8, the last value according to equation (5) can be checked:

$$\dot{V}_d = (303 - 121)\ W = 182\ l/h$$

This flow rate, which leads to the next branch point, is the initial value for TS 2 as the flow rate from TS 2 to the branch point, with TS 3 as the branch and TS 4 as the straight line, shown in the next line of the table. The calculations are then continued analog to the previous ones.

Selecting the pipe diameter for the DHW circulation lines
The nominal diameters for the DHW circulation lines are shown for each section in the table below. The lengths and flow rates of the individual circulation sections are the same as for the supply lines laid in parallel. These are shown in columns 3 and 4 of table 3 (page 22). Column 5 shows the flow rates converted from l/h to l/s.
The R-value tables are now used to select the nominal diameters of the circulation line, taking into account the maximum permitted flow speed of 0.5 m/s (columns 6 – 8). Once the pipework pressure drop (column 9) is determined, 40 % of the individual resistances are added to the pipe friction (column 12).

VORTEX

1	2	3	4	5	6	7	8	9	10	11	12	13
SECTION	PIPE	l [m]	$\dot{V}_z$ [l/h]	$\dot{V}_z$ [l/s]	d_a [mm]	v [m/s]	R [mbar/m]	l • R [mbar]	$\Sigma\zeta$	Z [mbar]	l•R+Z[1)] [mbar]	Δp_D [mbar]
TS 1	Cu	3	303	0.085	18	0.43	2.1	6			8	
TS 2	Cu	5	182	0.050	18	0.25	0.84	4			6	
TS 4	Cu	5	140	0.039	15	0.29	1.46	7			10	
TS 7	Cu	5	121	0.034	15	0.26	1.16	6			8	
TS 3	Cu	12	42	0.012	12	0.16	0.72	9			13	38
TS 5	Cu	12	53	0.015	12	0.19	1.05	13			18	23
TS 6	Cu	17	87	0.024	12	0.30	1.84	31			43	
TS 8	Cu	12	46	0.013	12	0.17	0.83	10			14	25
TS 9	Cu	17	75	0.021	12	0.26	1.66	28			39	

Table 3: Determining the pipe diameter for the DHW circulation line

[1)] 1.4 • l • R (+ 40 % from individual resistances, without non-return valve)

Calculating the manometric pressure for the DHW circulation pump

To calculate the manometric pressure according to equation (6), it is necessary to define the pressure losses due to friction and the pressure drops in the most unfavourable flow path (sections 1, 2, 4, 6). Add to this the 20 mbar pressure drop of the VORTEX non-return valve and the individual resistances with 40 % of pipe friction:

$$\Delta p_p = 1.4 \bullet (\sum l \bullet R_{TS\,1,2,4,6}) + \Delta p_{RV}$$

$$\Delta p_p = 1.4 \bullet (6 + 4 + 7 + 31)\ \text{mbar} + 20\ \text{mbar}$$

$$\Delta p_p = 87\ \text{mbar}$$

This provides the data for the DHW circulation pump: Delivery head: 0.87 m, pump rate: 0.303 m³/h

The following diagram **(Fig. 34)** was produced from the resulting data:

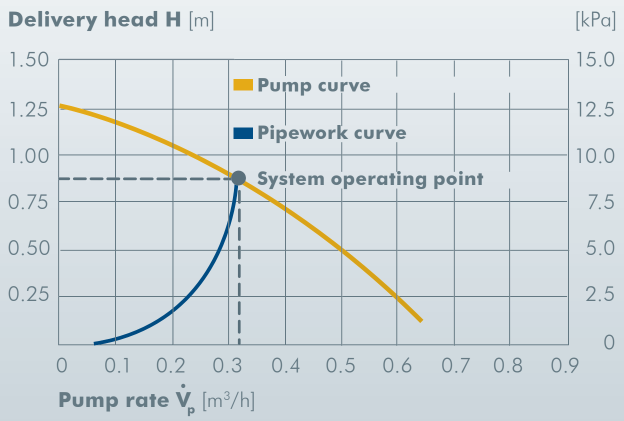

Fig. 34: Pipework curve and pump curve for sample calculation

Line balancing via line regulating valves

To ensure that the required temperatures are achieved in the individual lines and that all lines are subject to the same pressure drop, any excess pressure in individual lines is reduced via preset line regulating valves.
The excess pressure loss determined (column 13) is entered into the valve manufacturer's default settings diagram, together with the flow rate from the relevant line (column 4). This will determine the required default value.

5.7 DIFFERENTIATED METHOD ACCORDING TO DIN 1988-300

This method is suitable for any size of system, especially where system parameters are captured via computer software. It differs from the simplified method in that the heat losses and pressure drops are determined by differentiated calculations. This means that the default settings for the throttle valves can be calculated fairly precisely – although still based on assumptions!

In the differentiated procedure the individual calculation steps are carried out as follows:

1. Determination of heat losses in the DHW lines (subject to nominal diameter, insulation and room temperature)
2. Calculation of pump rate for the DHW circulation pump
3. Calculation of individual flows
4. Determination of nominal diameters for DHW circulation lines
5. Calculation of manometric pressure for DHW circulation pump via the differentiated pressure drops of the least favourable line
6. Choice of DHW circulation pump
7. Determination of default settings for line regulating valves.

6. HYGIENE REQUIREMENTS FOR PUMP OPERATION

6.1 LEGIONELLA RISK IN DOMESTIC HOT WATER

In unfavourable circumstances, germs and bacteria may proliferate in domestic hot water and present a danger to humans. Particular note should be taken of the strain Legionella pneumophila, which was first identified in 1976 and has since made the headlines worldwide time and again.

Legionella are rod-shaped bacteria, between 0.2 and 0.7 micrometres in diameter and 1 to 4 micrometres in length. To date more than 40 species and 50 subspecies have been identified.

Legionella have been proven to occur naturally in surface waters such as rivers and lakes, i.e. exclusively in fresh water. Rarely, legionella also occur in ground water. They have even been found in frozen rivers and in hot springs, i.e. under extreme climatic conditions. After initially being considered relatively rare, legionella are now known to occur in practically all waters apart from salt water. Ideal breeding conditions for legionella are within the temperature range of 25 to 45 °C. Above 50 °C, legionella can no longer survive and die off.

Apart from temperature, the growth of legionella is also dependent on other factors in the water, such as oxygen content, pH value, the proportion of metallic ions and electrolytes, and the pipework material. Legionella feed off dead microorganisms and can also form a symbiotic relationship with some types of algae, with reciprocal benefits for both.

In technical systems that treat or distribute water or that are operated using water (e.g. cooling towers, air-conditioning and DHW systems), contamination with high numbers of legionella bacteria can occur. The bacteria are transferred by superfine, moist aerosols, i.e. in the moisture/air mixture, for example when showering or using inhalation or respiratory apparatus and also in jacuzzis, near air humidifiers, open recooling plants and similar installations. Drinking contaminated water has also been identified as a source of infection in hospitals. The possibility of the bacteria transferring from person to person, however, can be ruled out.

The disease can progress in two distinct ways. One is referred to as Pontiac fever, a slight infection that does not affect the lungs and that subsides after a few days. There have been no known fatalities. Legionellosis (Legionnaires' disease) is far more dangerous. It is an acute bacterial inflammation of the lungs, which can be fatal. In principle, anyone can contract legionellosis. Those with weakened immune systems, however, are most at risk. Remarkably, three times more men than women fall ill from legionellosis. The risk of contracting the disease increases with age, as it does for smokers and diabetics.

6.2 THE NEW DRINKING WATER ORDINANCE – INSPECTION OBLIGATIONS

The key new features of the amendments to the TrinkwV, which came into effect on 1 November 2011 and 14 December 2012 respectively [1, 2], are the obligation to regularly inspect and display information about legionella in all buildings used for commercial purposes, not just public buildings. This includes rented residential properties, for example. Excluded from these obligations are all buildings defined as small installations, primarily because the potential risk is significantly lower in such settings.

Small installations include detached and two-family homes, regardless of the size of the boiler or the volume of water in the pipework. Any other building is considered a small system if the boiler capacity is no greater than 400 litres and the pipework capacity, measured from the boiler outlet of the DHW line to the furthest tapping point, does not exceed 3 litres.

Also excluded from the inspection obligations are large installations with no showers or shower attachments installed. This is because legionella only transfer to the human body when water is sprayed into the air to form a mist (see chapter 6.1).

Chapter 1 Chapter 2 Chapter 3 Chapter 4 Chapter 5 Chapter 6 Chapter 7

VORTEX

6.3 RECONCILING ENERGY-SAVING AND HYGIENE REQUIREMENTS WHEN OPERATING DHW CIRCULATION PUMPS

As mentioned in chapter 1.5.3, the EnEV stipulates that DHW circulation pumps must be equipped with self-actuating start/stop mechanisms. The aim is to restrict the runtime of the DHW circulation pump in order to save energy and help protect the environment.

At the same time, DHW installations must be designed and operated so that they are hygienically safe and do not present a danger to human health. With regard to the operation of DHW circulation pumps, there is often a requirement for pump runtimes to be as long as possible. This is because it prevents legionella growth due to unfavourable temperature conditions in some sections of the pipe network.

Advanced pumps and control concepts available on the market however, such as the self-learning Vortex **BlueOne** BWO 155 SL DHW pump (see chapters 2 and 3.3), allow pump runtimes to be significantly reduced in some cases, although this appears to contradict the claims regarding hygienic safety. Saving energy and good hygiene are, however, not mutually exclusive in principle.

In small installations (i.e. primarily detached and two-family homes), the probability of legionella occurring or growing still exists, but is considerably reduced, due to smaller boiler and pipework sizes and due to the relatively frequent exchange of water [10, 11]. For this reason, industry experts and even the German Federal Environment Agency (UBA) officially hold the view that small installations are excluded from the requirements of technical regulations as far as circulation is concerned [12–15].

This is also underlined by the fact that problem cases, including fatalities, have only occurred in large installations such as in hospitals, hotels or homes for the elderly to date. Due to the more complex pipe networks and larger water volumes involved, there is a considerably higher risk, especially as older systems frequently have weak points or the installation may be flawed. Furthermore, the above types of buildings often house people with weaker defence mechanisms and who are therefore at greater risk. In such buildings, additional preventative measures often need to be taken to avoid infection (e.g. flushing systems for hygiene or fitting terminal filters).

If the regulatory text in DVGW Code of Practice W 551 is nevertheless taken as a benchmark also for small installations, at the same place there is an indication that other technical measures and procedures may be applied to attain the declared aim of the Code of Practice (i.e. to reduce legionella growth).

A regular disinfection cycle that includes the DHW circu-

lation system is one such measure. For this reason the VORTEX pump versions with self-learning module are equipped with a relevant function (disinfection run detection). Provided that the DHW heater control unit regularly heats the boiler up to suitably high temperatures (e.g. 70 °C), the pump performs a short disinfection run so that the entire circulation loop is supplied with water of this temperature. These pumps also carry out automatic purges if the user is away for an extended period (holiday detection). Thanks to this technology, the "eight-hour rule" (according to DIN 1988-200 or DVGW Code of Practice W 551 DHW circulation pumps should be switched off for a maximum of 8 hours per day) is not a stringent stipulation.

With large installations, the requirement for proof that hygiene conditions are met, as stipulated by Code of Practice W 551, is fulfilled by the investigation obligations outlined in the TrinkwV (see above). Appropriate findings provided even large installations may be operated with shorter pump runtimes [16, 17].

This inspection obligation does not exist for small installations (see chapter 6.2), but hygiene conditions can be considered sound if the DHW system is planned, implemented and operated according to the requirements of W 551 or if modernised systems likewise meet these conditions [16, 17]. This includes in particular adhering to the minimum boiler temperature (recommendation: 55 °C), avoiding stagnant sections, ensuring hydraulically balanced circulation and proper insulation to cite the key points.

If these specifications are not or only partially met, pump control involving very short pump runtimes is not advisable for reasons of both comfort and hygiene. VORTEX provides a wide range of pump controls incorporating a variety of characteristics and adjustment options, enabling the most appropriate solution to be found for every application (table 4, see also page 7).

Ultimately, however, the user of the small installation is responsible for choosing how and with which control variant he operates his DHW pump. The provider (installer) is therefore obliged to point out any potential risk of a legionella infection, for example due to an unfavourable system configuration or if the system is being used incorrectly. If in doubt, the user should be asked to sign a transfer and acceptance log to confirm that they understand the risk.

			
BWO 155 SL	**BWO 155 Z**	**BWO 155 ERT**	**BWO 155**
✔ Can run continuously ✔ Speed adjustable ✔ Automatic disinfection run detection ✔ Automatic purges ✔ Automatic operation (**AUTO***learn*)	✔ Can run continuously ✔ Speed adjustable ✔ Runtimes adjustable	✔ Can run continuously ✔ Speed adjustable ✔ Cut-off temperatures adjustable ✔ Can be operated via external time switch	✔ Can run continuously ✔ Speed adjustable ✔ Can be operated via external time switch

Table 4: VORTEX high efficiency pump models **BlueOne**

VORTEX

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COMPANY HISTORY – MANUFACTURER OF DHW PUMPS SINCE 1965

1965 Deutsche VORTEX GmbH is founded on 1 April 1965

The first DHW pump is named: The V 100 is a hermetically sealed magnetic clutch pump with an integrated thermostat.

1975 VORTEX presents the BW 150, the first pump with a revolutionary motor principle – the spherical motor.

1980 The BWZ 150 is the world's first DHW pump with integrated time switch. VORTEX integrates the non-return valve and ball shut-off valve in the pump housing.

1985 Heating pumps and a DHW pump with a delivery head of 3.50 m complement the product range.

1987 Balancing of branched circuits by means of automatic VORTEX circulation control valves.

1991 VORTEX DHW pumps with digital time switch and electronic thermostat

1996 Rotatable 360° time switches are launched with the BW/BWZ 152/153 series. The VORTEX venting flange simplifies the venting of DHW circulation systems.

1997 Certification of quality management system

2000 VORTEX website goes live: **www.deutsche-vortex.de**

2004 VORTEX BWM 153 DHW pump with multifunction module: Five permanently stored programmes, electronic thermostat, legionella control (BWM 153+) and much more.

2008 VORTEX BW-SL 154 DHW pump with **AUTO***learn* technology: This pump independently learns the times when DHW is drawn (optimum supply with minimal energy requirements).

2011 The new **BlueOne** (BWO 155) high efficiency pump generation comes onto the market, with a power consumption of just 2.5 to 9 watts.

2013 New **BlueOne** universal motors – suitable for all commonly available pump housings.

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