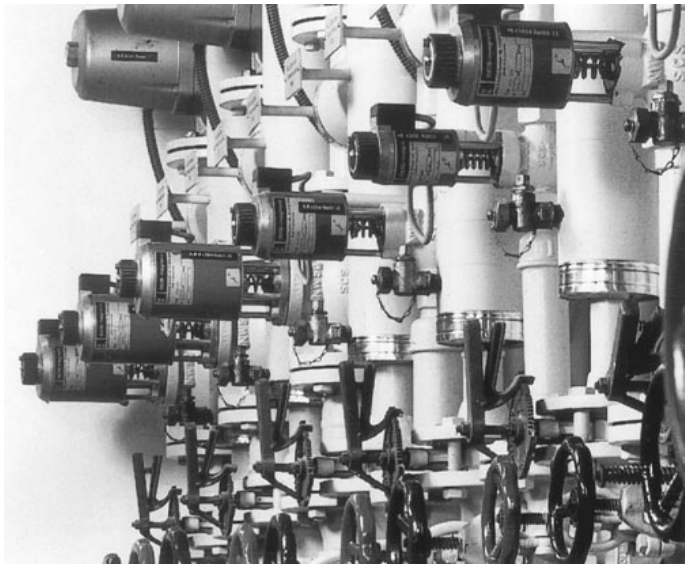
Valve selection - General

(original product range of
Staefa Control System)



Staefa Control System supplies various types of valve bodies and actuators. These are designed for special control applications in heating, ventilation and air conditioning systems.

Actuators

The special features of the individual actuators are as follows:

- Valve actuator
- Valve body

} Valve

Actuators:

The special features of the individual actuators are as follows:

Magnetic actuator:

– Robust, maintenance free, friction free
– Short positioning time
– High resolution
– Type of operation: modulating

Thermic actuator:

– Robust, maintenance free
– Two-wire connection (interchangeable)
– High operating temperature of solid expansion medium actuator
– Type of operation: modulating

Motorised actuator:

– Force operated end switch-off
– High positioning force
– Type of operation: modulating or three-point

Valve bodies

The *valve bodies* are availble with flanged, screwed or soldered connections. They are suitable for various media, and various pressure, temperature and volume ranges.

The *valves* are tight closing control elementswhich are especially suitable for modulating control. They are available in different versions to suit particular requirements. In pump circuits, three-way vales aire preferable to straight-through valves since constant volumes of ciculating water have certain advantages in control engineering.

The information in the data sheets (for disc/plug valves) relates to control via ports 1 → 3. *These are the control ports*, in this case the valves will be tightly sealed in the closed position. Control via ports 2 → 3 will result in leakage, the rate of which depends on operating conditions. For special cases, in which control is via ports 2 → 3, Landis & Staefa should be consulted.

Further information is available from the manufacturer upon request.

Slipper (or "rotating shoe") valves are used almost exclusiveley for mixing control in heating systems. The admissible pressure differentials are low, the leakage rate, however, is relatively high.

Butterfly valves are used for open/closed functions, e.g. in boiler sequencing control circuits. The pressure differential accross the open valve is very low, and the leakage flow accross the closed valve is relatively high. Normal butterfly valves are not suitable for modulating control.

Definitions and characteristics

Nominal pressure PN

The pressure for which valve bodies are designed. The nominal pressure is used to define e.g. the valve body material, the temperature of the medium used, valve sizing (e.g. flange dimensions) and the regulations etc.

Operating pressure $p_{e}max$

This is the maximum pressure to which the valve may be subjected. The pressure can depend on the temperature.

Closing pressure $\Delta p_{V}max$

The highest permissible pressure differential across the closed valve. Where $\Delta p_{V}max$ is not mentioned, the closing pressure is equivalent to the pressure differential $\Delta p_{V}max$.

Pressure differential $p_{e}max$

The highest permissible pressure differential at which the valve is controllable in modulating fashion. If the $\Delta p_{V}max$ exeeds this limit, the flow behaviour can change, causing noise and high wear of the throttle element.

Temperature limits

These have to be observed for the medium and the environment. The limits may also depend on the operating pressure and the mounting position.

k_{v} -value

The k_{v} value is defined as the flow (measured in m^3/h) of a liquid medium (with a density $\rho \approx 1000$ kg/m^3 and a kinematic viscosity $\upsilon \approx 10^{-6}$ m^2/s) through a valve open at a stroke (H) with a pressure loss of 1 bar.

k_{vo} -value

The k_{v} value at stroke 0, eqivalent to leakage.

k_{vs} -value

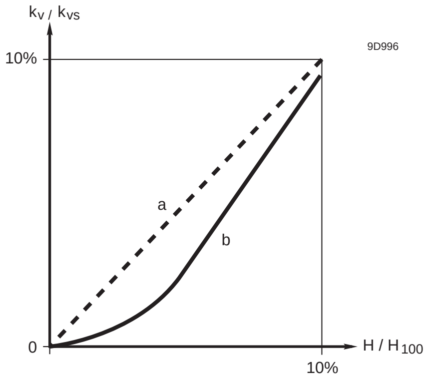
This is the designed k value of a valve series with a nominal stroke (100 %). In accordance with the courrently used standards this value may have a tolerance of ±10 %.

Valve characteristic

Disc valves have an approximately linear characteristic (ports 1→ 3). This characteristic is optimised in the lower closing range (below 10 % stroke) i.e. it is possible to control the smallest flow rate (see diagram). The maximum jump on start-up would only be equivalent to the leakage, i.e. in most cases it would be negligible as far as the control behaviour is concerned.

For this reason a definition of the rangeability in accordance with VDI/VDE 2173 is not necessary.

For any calculations of the control behaviour of disc valves the rangeability can be replaced by k_{vs} / k_{vo} which is a very good approximation.

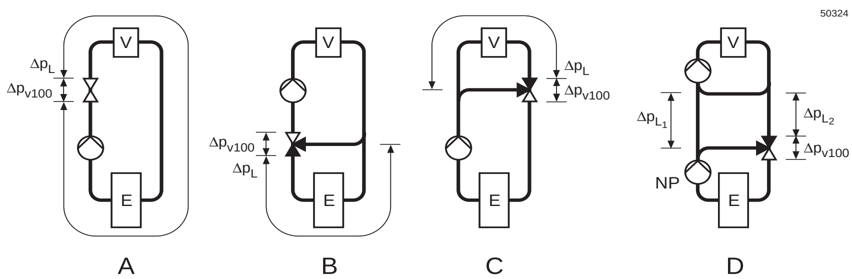


a : Linear characteristic (theoretical)
b : Characteristic of 'Staefa' disc valves

Sizing

The behaviour of a modulting system largely depends on the sizing of the control valve. The control valve is optimally sized when the full power of the system is reached when the valve is fully open. The determining factor for the control stability in this status is the valve authority:

$$p_v = \frac{\Delta p_{v100}}{\Delta p_L + \Delta p_{v100}}$$



A Throttle circuit
B Mixing circuit
C Diverting circuit
D Injection circuit

In the injection circuit:

Δp_{v100} Pressure loss across the fully open valve at a nominal volume flow

Δp_L p_{L1} + p_{L2} = Pressure loss of variable volume section at a nominal volume flow

E Generator

NP Circuit pump

V Consumer

Sizing for water and similar liquid media

Pumps and valve bodies must be sized such that p_v is ≥ 0.5, i.e. :

The pressure loss across the open valve (Δp_{v100}) must be equal to or greater than the preuss loss of the variable colume section (Δp_L).

In mixing and injection circuits Δp_L is noormally so small, that the valve may be sized according to the nominal pipe diameter or even smaller.

With injection circuits, the circuit pump NP must be able to overcome $\Delta p_{v100} + \Delta p_L$.

Sizing for steam and gaseous media

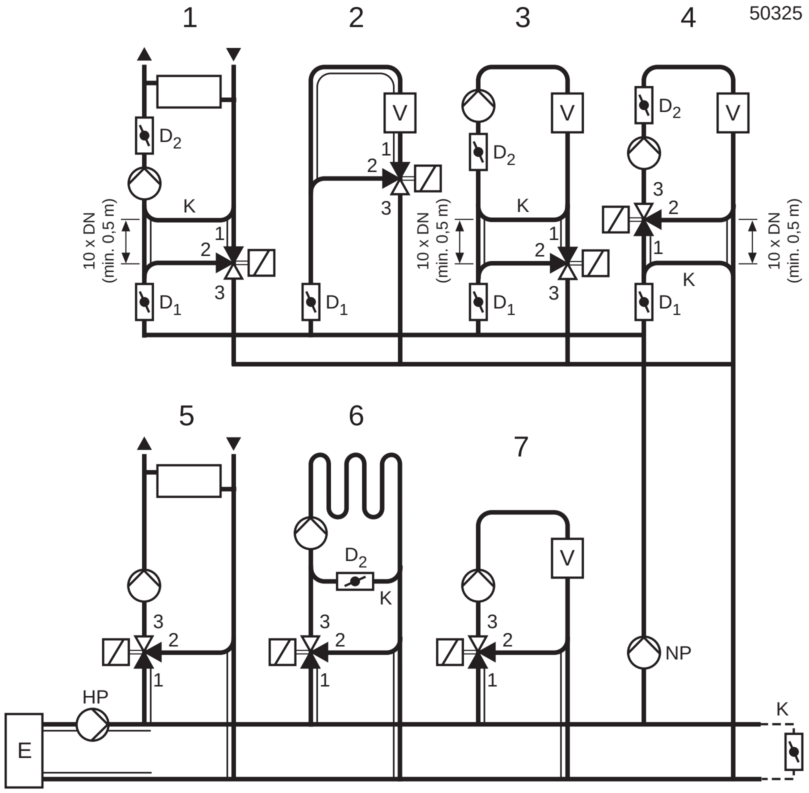
Important:

The pressure losses across the valve (Δp_v), must not exceed the admissible limits (Δp_{vmax}).

The maximum possible flow rate of steam valves is reached when the so-called critical velocity is reached in the throttle section. This is the case when the pressure loss across the valve is approximately 42 % of the absolute inlet pressure p_1. It is therefore advisable to size steam control valves for critical pressure conditions.

With low pressure steam, (i.e. inlet pressures below 2 bar absolute) it may occassionally be necessary to size the valve below the critical point. 20 % valve pressure loss must however be regarded as the minimum limit.

Hydraulic circuits for LTHW and CHW systems



E *Generator*
NP *Circuit pump*
HP *Main pump (requires bypass distibution headers for circuits 5, 6 and 7)*
K *Bypass (Δp < 5 mbar at max. water volume)*
D1 *Balancing throttle for supply water volume*
D2 *Balacing throttle for circulating water volume*
=== *Variable volume section (Δp_L), which determines the valve size*

Mains connections

1 Injection circuit for radiators and convectors. Nominal valve size ≤ nominal diameter of pipe.
2 Diverting circuit for heat exchangers, e.g. reheaters and coolers $\Delta p_{V100} \geq \Delta p_L$.
3 Injection circuit for large heat exchangers and preheaters. Nominal valve size ≤ nominal diameter of pipe.
4 Mixing circuit for heat exchangers situated a long distance from the distribution header. Nominal valve size £ nominal diameter of pipe.

Distribution header connections

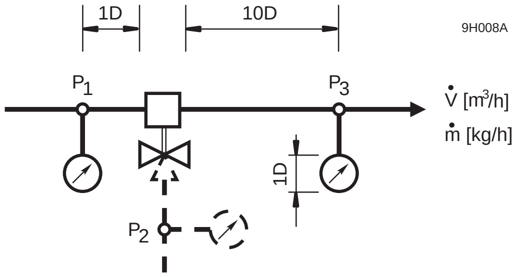
5 Mixing circuit for radiators and convectors. Nominal valve size ≤ nominal diameter of pipe.
6 Mixing circuit with bypass for underfloor heating. Nominal valve size ≤ nominal diameter of pipe.
7 Mixing circuit for heat exchangers situated close to the distribution header. Nominal valve size ≤ nominal diameter of pipe.

Mounting

- Never allow 2 pumps to act on a 3-way valve (bypass one pumpe as indicated by "K").
- Instructions relating to the direction of flow must be oberserved.
- Magnetic valves in de-energised position close port 1 → 3 by means of a spring.
- Port 2 → 3 must not be used as a reliably tight connection. For special applications with control via port 2 → 3, Landis & Staefa must be consulted.
- The valves must be mounted so that no water can penetrate into the actuator.
- The mounting position may depend on the temperature of the medium. Observe mounting instructions, particularly at media temperatures of above 110 °C.
- To avoid parasitic circulation, the distance from the distribution point to the bypass K or return header must be at least 10 x DN or 0.5 m, (whichever is the greater).

Calculation

The hydraulic properties of the valve are calculated by means of the flow coefficient k_v (or c_v).



$p_1 (p_2)$	=	Absolute pressure in bar (at inlet)		
p_3	=	Absolute pressure in bar (at outlet)		
$\frac{p_1 - p_3}{p_1}$	=	Pressure ratio		
$\dot{V}$	=	Water flow rate in m^3/h		
$\dot{m}$	=	Refrigerant volume or steam volume in kg/h		
x	=	Refrigerant factor		
		x - values for:	R134a	0,0138
			R22	0,0162
			R500	0,0156
			R507	0,0147
			Ammonia	0,0364
k	=	Superheating factor = 1 + 0,0013 ΔT		
ΔT	=	Superheating temperature = $t_{steam} - t_{saturated\ steam}$		

If the required flow rate $\dot{V}$ or $\dot{m}$ and the necessary pressure differential across the valve are known, the k_v value may be calculated with the help of the formulae below.

Once the k_v value has been calculated, the valve with the k_{vs} value immediately below this should be selected. In most cases, the calculations allow for this diferential, so that the selected valve can achieve optimum efficiency.

Water:

$$k_V = \frac{\dot{V}}{\sqrt{p_1 - p_3}}$$

Refrigerant:

$$k_V = \frac{x \cdot \dot{m}}{\sqrt{p_3\,(p_1 - p_3)}}$$

Steam:

a) Pressure ratio < 0,42 (< 42 %), below critical pressure drop

$$k_V = 0{,}042 \cdot \frac{\dot{m}}{\sqrt{p_3\,(p_1 - p_3)}} \cdot k$$

b) Pressure ratio > 0,42 (> 42 %), above critical pressure drop

$$k_V = 0{,}084 \cdot \frac{\dot{m}}{p_1} \cdot k$$

Examples of valve selection

a) below critical pressure

Given:

Superheated steam t	=	153.5 °C
Inlet pressure p_1	=	3.0 bar
Steam volume $\dot{m}$	=	110 kg/h
Saturated steam temperature	=	133.5 °C
Superheating ΔT	=	20 K
Pressure ratio	=	0.12

Required: k_V value, valve type

Solution:

$p_3 = p_1 - 0.12\, p_1 = 2.64$ bar

$k = 1 + 0.0013 \cdot 20 = 1.026$

$$k_V = 0.042 \cdot \frac{110}{\sqrt{2,64\ (3-2,64)}} \cdot 1.026 = 4.86$$

Valve type: M2H20 ($k_{VS} = 5$)

b) above critical pressure

Given:

Saturated steam t	=	133.5 °C (k = 1.0)
Inlet pressure p_1	=	3.0 bar
Steam volume $\dot{m}$	=	110 kg/h
Pressure ratio: admissible, above critical	≥	0.42

Required: k_V value, valve type

Solution:

$$k_V = 0.084 \cdot \frac{110}{3} \cdot 1 = 3.08$$

$p_3 \leq (1 - 0.42) \cdot 3 \leq 1.74$ bar

Valve type: M2H15 ($k_{VS} = 3$)