Design of Safety Valves
Design standard: DIN EN ISO 4126-1

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Objective of the presentation. Design of Safety Valves – DIN EN ISO 4126-1.

The objective of the presentation is to show the **design of safety valves** in compliance with ISO 4126-1.

- **Standard specifications for the design** of safety valves
- **Formulas for the design** of safety valves
- **Factors Influencing the stability** in operation

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National and international standards. For calculation of safety valves.

Calculation levels of safety valves

ISO 4126-1	AD 2000 - Merkblatt A2	API 520	ASME VIII

Calculation levels of inlet pressure loss and back pressure

ISO 4126-9 Chapter 7 + 9	AD 2000 - Merkblatt A2 Chapter 6

What impact does this have on the user?

Size determination	

Size determination

- **ISO 4126-1** must be applied in the **European region** for size determination of safety valves
- TRBS is not yet available for specification of the safety valve

inlet pressure loss

- There is no effect on the capacity and function up to a pressure loss of 3%
- Pressure losses >3% must be taken into account in the capacity calculation. The operation may be affected.

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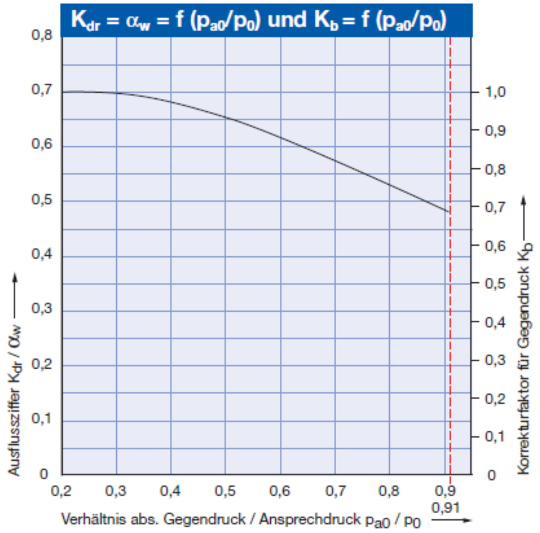
What impact does this have on the user?

Back pressure

- Effect on the capacity taking the p_{ao}/p_o curve into consideration
- This ratio is observed for absolute pressures.



- Capacity minimisation must also be taken into consideration for low set pressures.
- p = 03 bar g (set pressure)
- p_{ao} = 1.013 bar a (ambient pressure)
- p_o = (0.3 barg + 0.1 barg + 1.013 bar a) (pressure in the system to be secured)
- p_{ao} / p_0 = 1.013 bar a / (0.3 barg +0.1 bar g + 1.013 bar a) = 0.72
- >> K_b = 0.81

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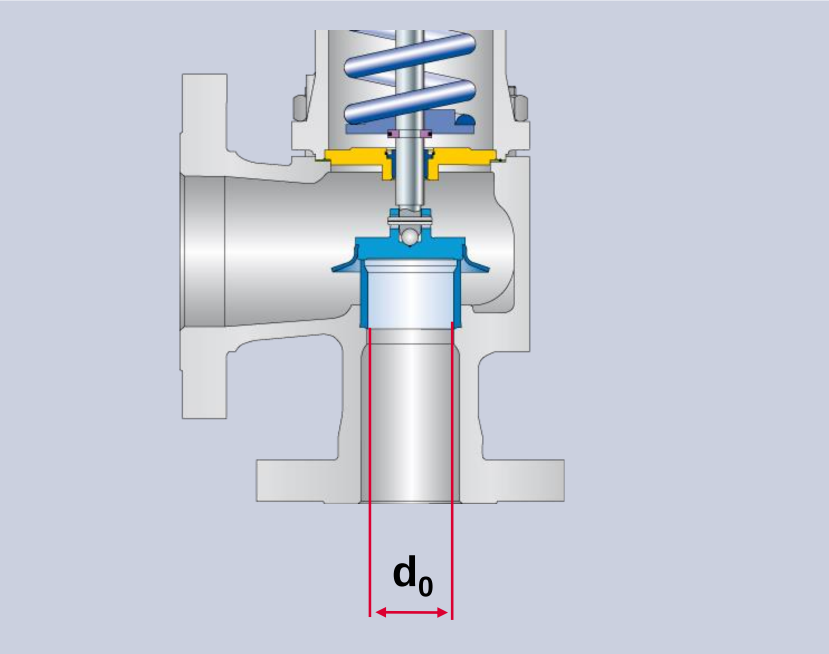
What parameters are important for the design, and how are they related?

High Performance



- **Coefficient of discharge α_w:**
  (k_{dr} acc. to ISO 4126-1)
  the rated coefficient of discharge from component testing (often also referred to as α_d)
- **Orifice area A_0:**
  actual orifice area
- **Substance information**
  medium-dependent substance data
- **Operating data:**
  state parameters like pressure and temperature

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Coefficient of discharge and rated coefficient of discharge.

	German Code	American Code
	VdTÜV Merkblatt SV 100, § 3.3.1	**ASME-Code Sec.VIII, Div. 1, UG-131 (e)**
Coefficient of discharge	$\alpha = \dfrac{q_{measured}}{q_{theoretical}}$	$K_d = \dfrac{q_{measured}}{q_{theoretical}}$
Rated coefficient of discharge	$\alpha_w = 0.9 \ x \ \alpha$	$K = 0.9 \ x \ K_d$

- $q_{measured}$ = actual measured q_m
- $q_{theoretical}$ = calculated q_m
- α or K_d = coefficient of discharge
- α_d or K = rated coefficient of discharge
- 0.9 = correction factor

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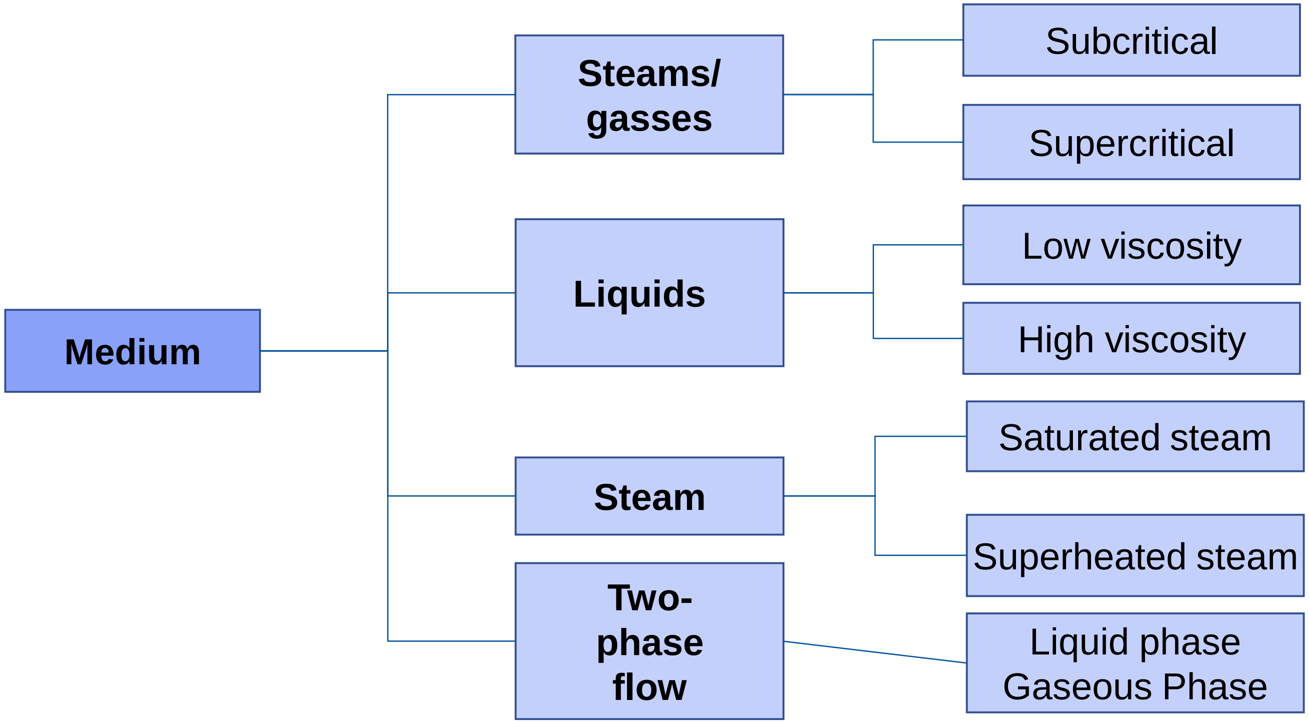
Differentiation of media.



Required data on materials.

		Gasses / steams	Liquids	Saturated steam	Superheated team
Set pressure p_{set}	psig	x	x	x	x
Back pressure p_a	psig	x	x	x	x
Temperature T	[°C]	x			x
Mass flow* q_m	[kg/h]	x	x	x	x
Volumetric flow rate* q_v (while operating)	[m³/h]	x	x	x	x
Volumetric flow rate* q_v	[Nm³/h]	x			
Overpressure c	[%]	x	x	x	x
Real gas factor Z	[-]	x			
Molar mass M	[kg/kmol]	x			
Isentropic exponent k	[-]	x			
Density ρ	[kg/m³]		x		
Kinematic viscosity ν	[m²/s]		x		

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Design for gasses / steam as per DIN EN ISO 4126-1.

ISO 4126-1

$$A = \frac{Q_m}{C \cdot K_{dr} \cdot p_0} \cdot \sqrt{\frac{Z \cdot T}{M}}$$

ISO 4126-1	
▪ Actual orifice area	**A [mm²]**
▪ Mass flow	**Q_m [kg/h]**
▪ Functional isentropic exponent	**C [-]**
▪ Rated coefficient of discharge	**K_{dr}**
▪ Set pressure	**p_0 [bar abs]**
▪ Temperature	**T [K]**
▪ Molar mass	**M [kg/kmol]**
▪ Real gas factor	**Z [-]**

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Design for saturated steam as per DIN EN ISO 4126-1.

ISO 4126-1

$$A = \frac{Q_m}{C \cdot K_{dr} \cdot 0.2883} \cdot \sqrt{\frac{v}{p_0}}$$

ISO 4126-1	
Actual orifice area	**A [mm²]**
Set pressure	**p_0 [bar abs]**
Functional isentropic exponent	**C**
Mass flow	**Q_m [kg/h]**
Specific volume	**v [m³/kg]**
Rated coefficient of discharge	**K_{dr} [m³/kg]**

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Design for saturated steam as per DIN EN ISO 4126-1.

ISO 4126-1

$$A = \sqrt{\frac{v}{p0 - pb}} \cdot \frac{Q_m}{1.61 \cdot K_{dr} \cdot K_v}$$

ISO 4126-1	
▪ Actual orifice area	**A [mm²]**
▪ Set pressure	**p_o [bar abs]**
▪ Back pressure	**p_b [barü]**
▪ Mass flow	**Q_m [kg/h]**
▪ Specific volume	**v [m³/kg]**
▪ Rated coefficient of discharge	**K_{dr}**
▪ Viscosity correction factor	**K_v**

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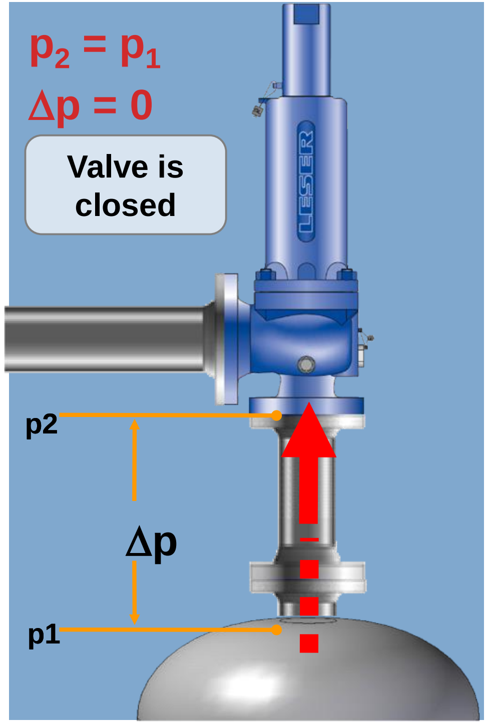

$p_2 = p_1$
$\Delta p = 0$
Valve is closed
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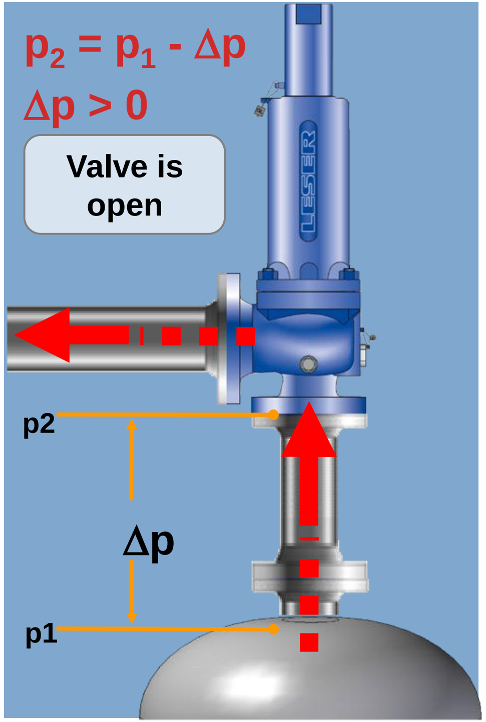
p2
Δp
p1



$p_2 = p_1 - \Delta p$
$\Delta p > 0$
Valve is open
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p2
Δp
p1

Inlet pressure loss. Standards and Codes.

- A **maximum pressure loss of 3%** from the vessel to the safety valve is permissible for the most common international standards and codes.

- **ISO 4126-9 Chapter 6.2**
  Unless otherwise specified by national codes or regulations, the inlet line shall be so designed that the total pressure drop to the valve inlet does not exceed 3 % of the set pressure of the safety device,…

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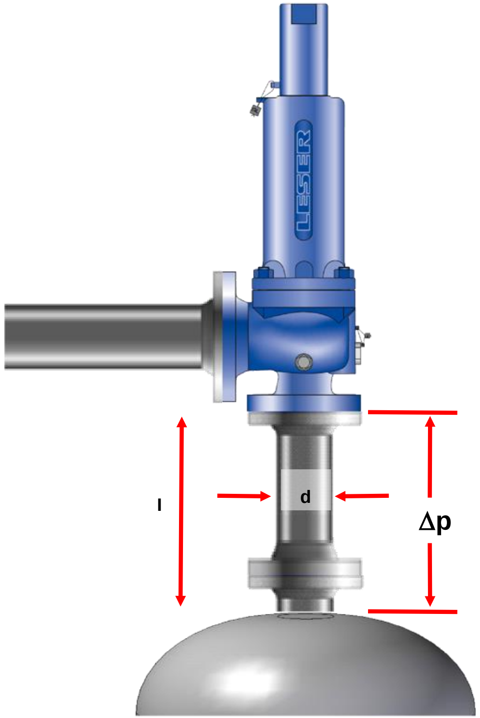
Calculation.



$$\Delta p = \underbrace{(\lambda \cdot l/d + \Sigma\zeta)}_{\text{Flow resistance}} \cdot \underbrace{\rho/2 \cdot w^2}_{\text{Flow rate}}$$

- λ = Pipe friction coefficient (pipeline)
- l/d = Length and diameter of a pipe
- ζ = Friction coefficient (components)
- ρ = Density
- w = Speed

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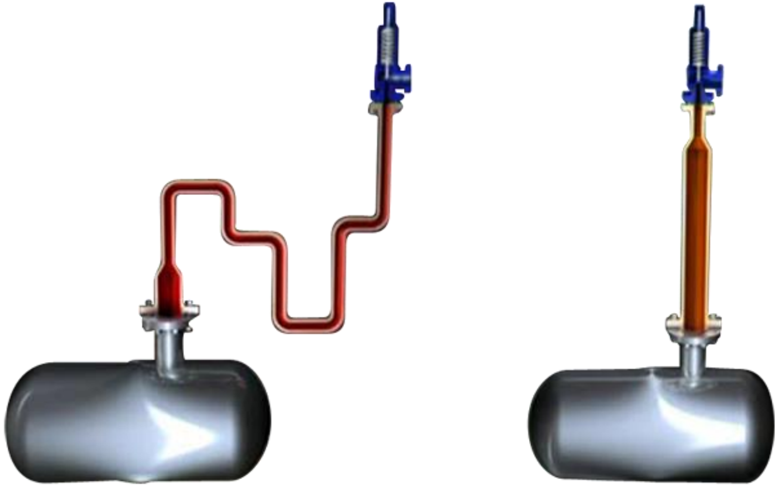
Inlet pressure loss.

The following **measures prevent malfunctions** that are caused by an inadmissible **inlet pressure loss**:

- **Reduction of the flow rate through**
  - increasing the pipe diameter
  - reducing the mass flow through a smaller valve
  - reducing the mass flow through a lift stopper
  - reducing the mass flow through an O-ring-damper



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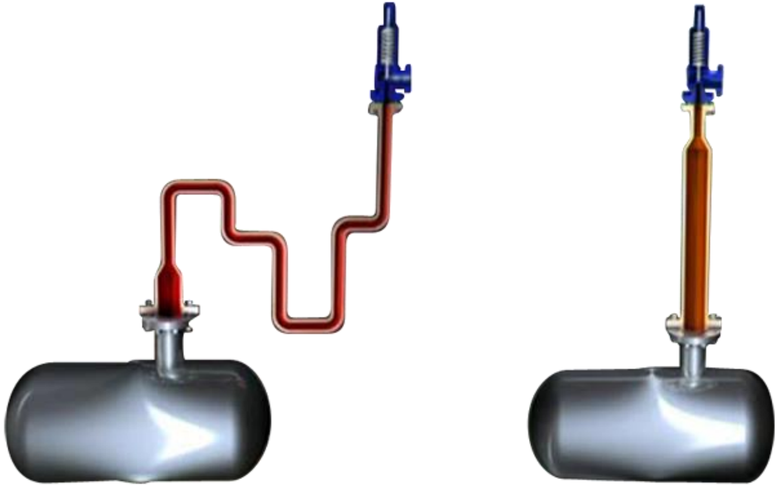
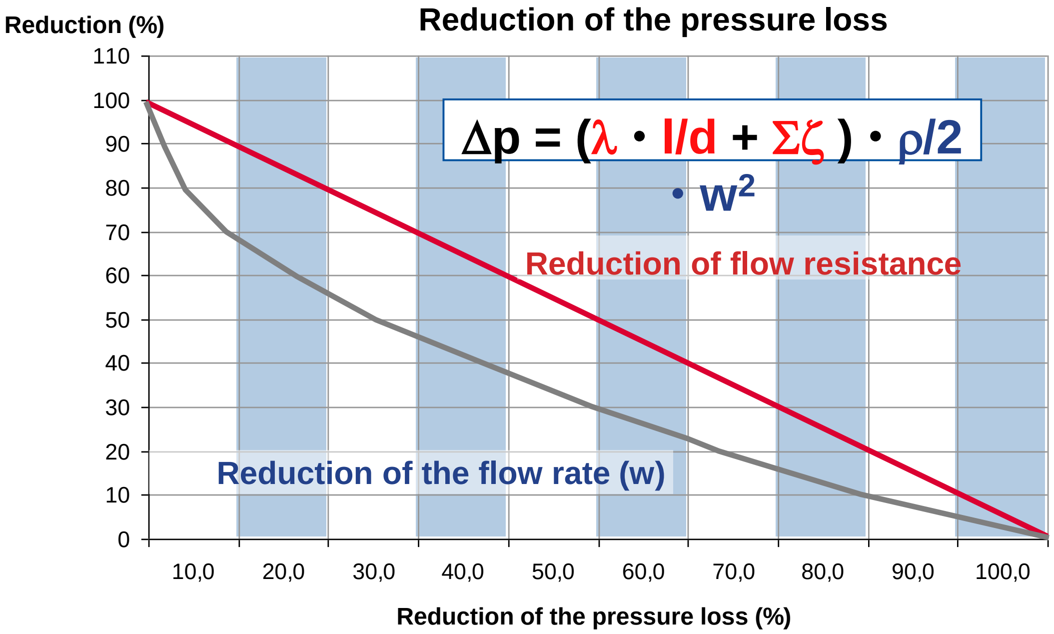
Inlet pressure loss.

- **Reduction of the flow rate through**
  - shorter inlet pipeline
  - low-resistance connection to the vessel



Inlet pressure loss.

Reduction of the flow rate is **more effective** than **reduction of the flow resistance**



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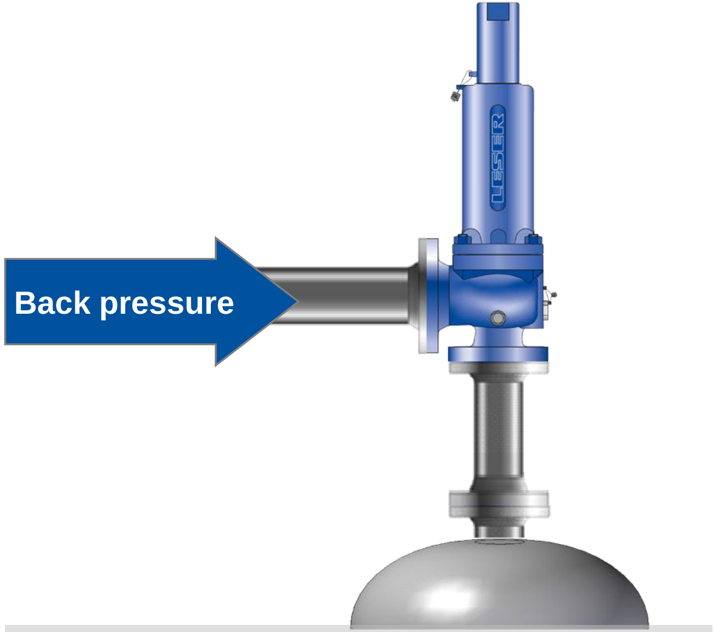
Back pressure. Definition

Back pressure

- **Built-up back pressure**
- **External back pressure**
  - **Constant**
  - **Variable**

Exists only in the outlet **while** the **safety valve blows off.** It is dependent on the flow loss in the discharge line.

Exists permanently in the outlet system The external back pressure is dependent on the blow-off of the safety valve



Back pressure = built-up back pressure + external pressure

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Back pressure – stability. Setting.

The following **measures prevent malfunctions resulting from the back pressure**:

- **Constant back pressure**
  - settings to differential set pressure (CDTP)
  - use of stainless steel bellows
- **Variable back pressure**
  - use of stainless steel bellows

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Design of Safety Valves
Thank you for your attention.