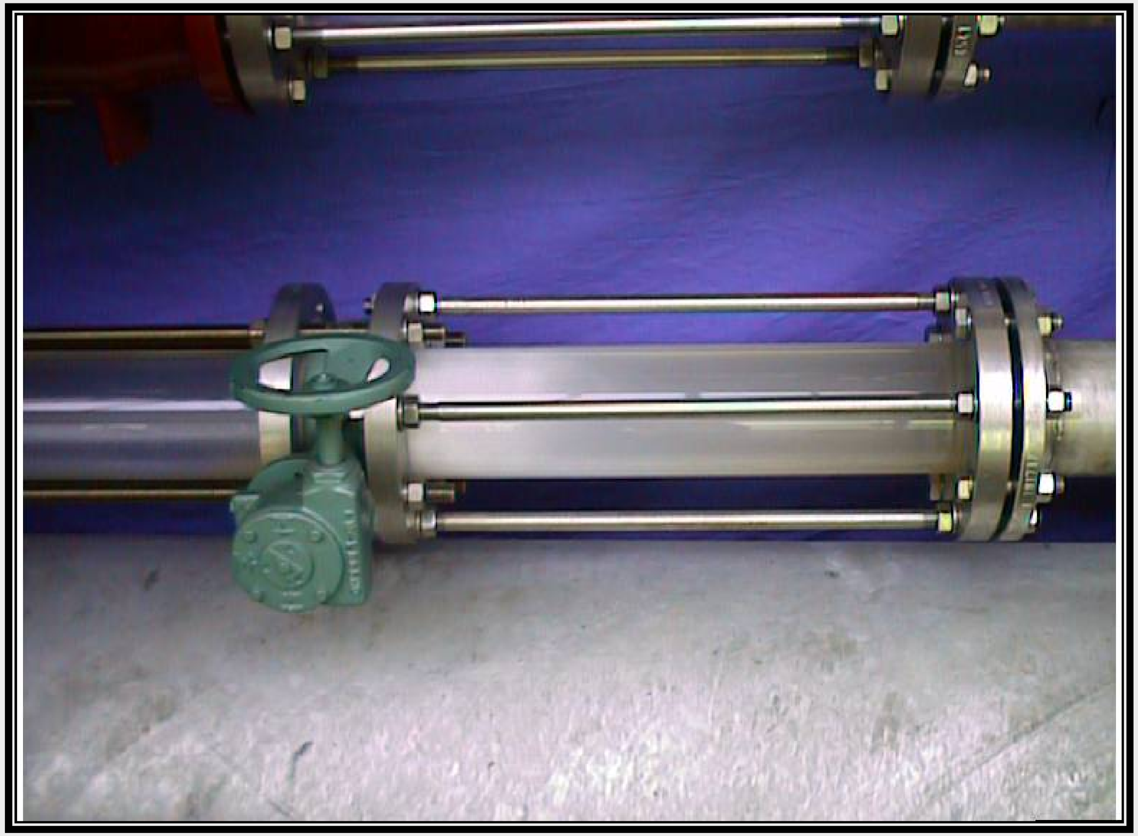
ERHARD
VALVES

VALVE & PIPELINE CAVITATION



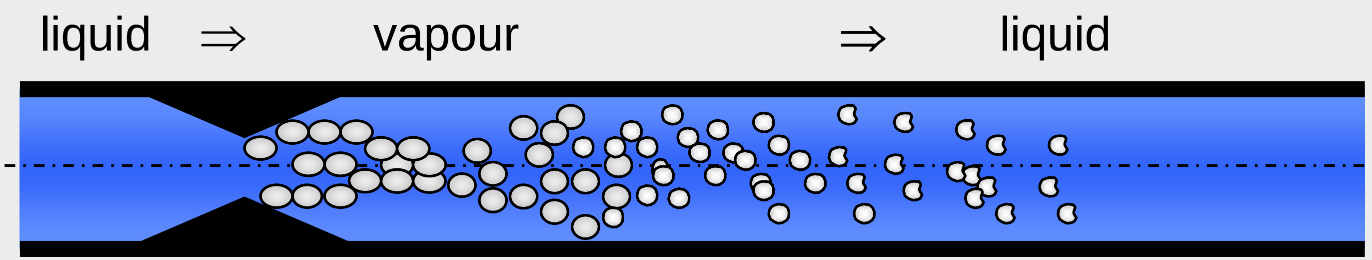
What is cavitation ?

Cavitation is a physical process, which can arise in liquids. It describes the phase transition between the liquid and the vapour condition.

The process of cavitation has two steps:

1. step: Change from **liquid condition** into **vapour condition**.

2. step: Change from **vapour condition** into **liquid condition**.



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Where can cavitation arise ?

Cavitation can arise in all media, where a change between a liquid condition and a vapour condition is possible.

Cavitation can arise in case of a high variation of the flow velocity.

Examples:

At moving parts:

- **vanes of turbines**
- **pump impellers**
- **propellers of ships**

At non-moving parts:

- **sudden reduction of pipe cross section**
- **throttling by means of orifices**
- **throttling procedures in valves**

The following describes **throttling procedures in valves** only. These procedures are transferable to all other given examples.

What is the effect of cavitation ?

Three stages:

- Loud and pelting noise.
- Vibrations.
- Erosion of material (damages due to cavitation).

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Typical cavitation damages

Cavitation damages at a butterfly valve.

Operating conditions:

- upstream pressure: 1.2 -1.4 bar
- downstream pressure: 0.1 bar
- flow velocity: 2.2 m/s (referred to DN)
- duration of operation: 2 years
- opening degree of disc: approx.: 30°

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Typical cavitation damages

Cavitation damages at a gate valve.

The gate valve was not closed completely. In the remaining gap, the flow velocity was very high. After three months operation, the valve body was damaged as shown in the picture.

Typical cavitation damages

Cavitation damages at an angle pattern valve.

The valve was used for filling-up a reservoir. At the valve outlet, a pipe was flanged which was ending below the water level. This caused cavitation at the throttling point.

The damages can be seen in the picture.

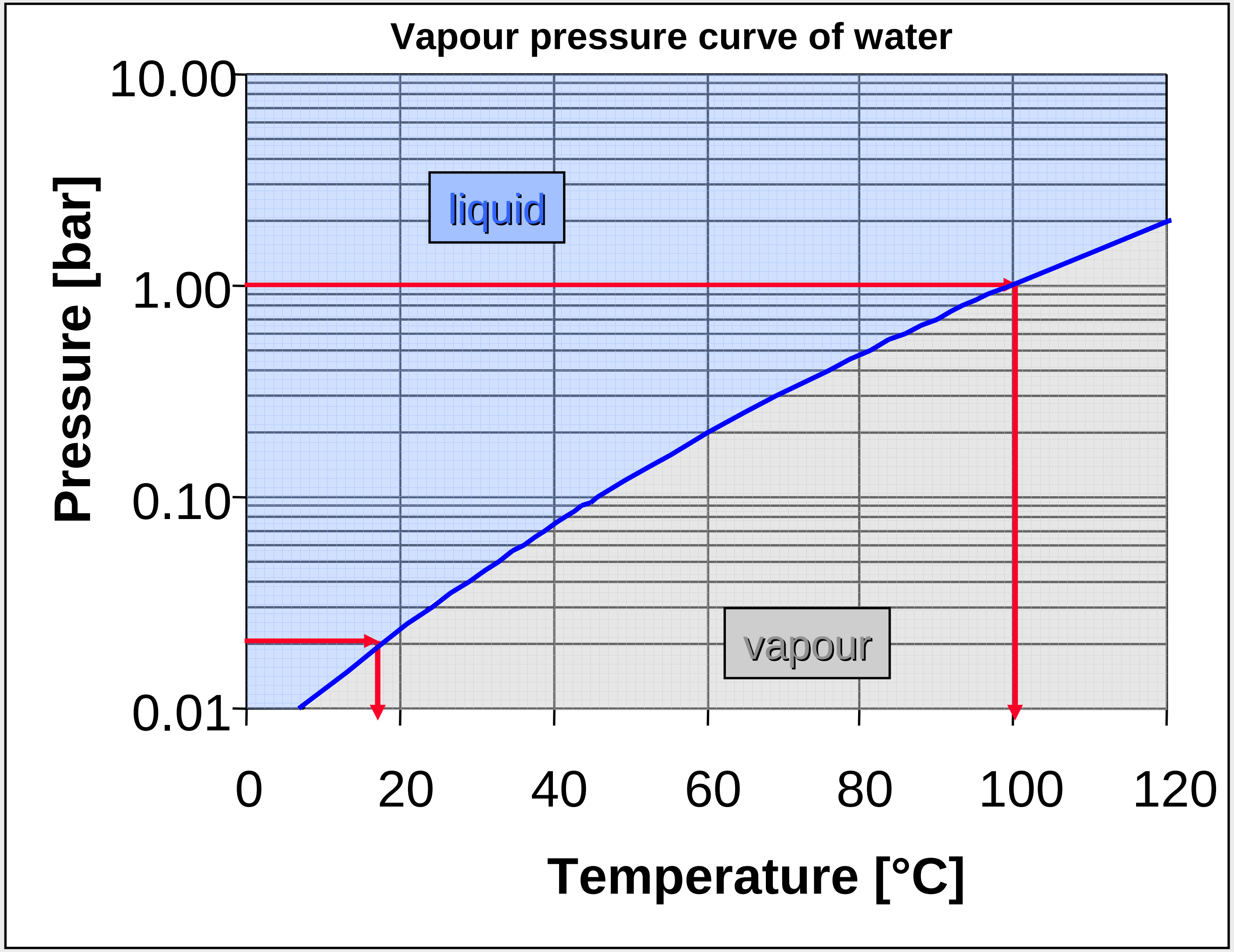
When does water evaporate ?

At atmospheric pressure (1 bar) water evaporates at 100°C.

When the pressure decreases, the evaporation process already starts at low temperatures.

Example:

At a pressure of 0.02 bar water evaporates already at a temperature of 18°C.



Energy content of a flow medium

The total energy of a flow medium is basically composed of the following individual types of energy:

The sum of this individual energy types is constant!

Potential energy
Pressure energy
Velocity energy
Loss energy

+

Σ constant

Bernoulli´s law

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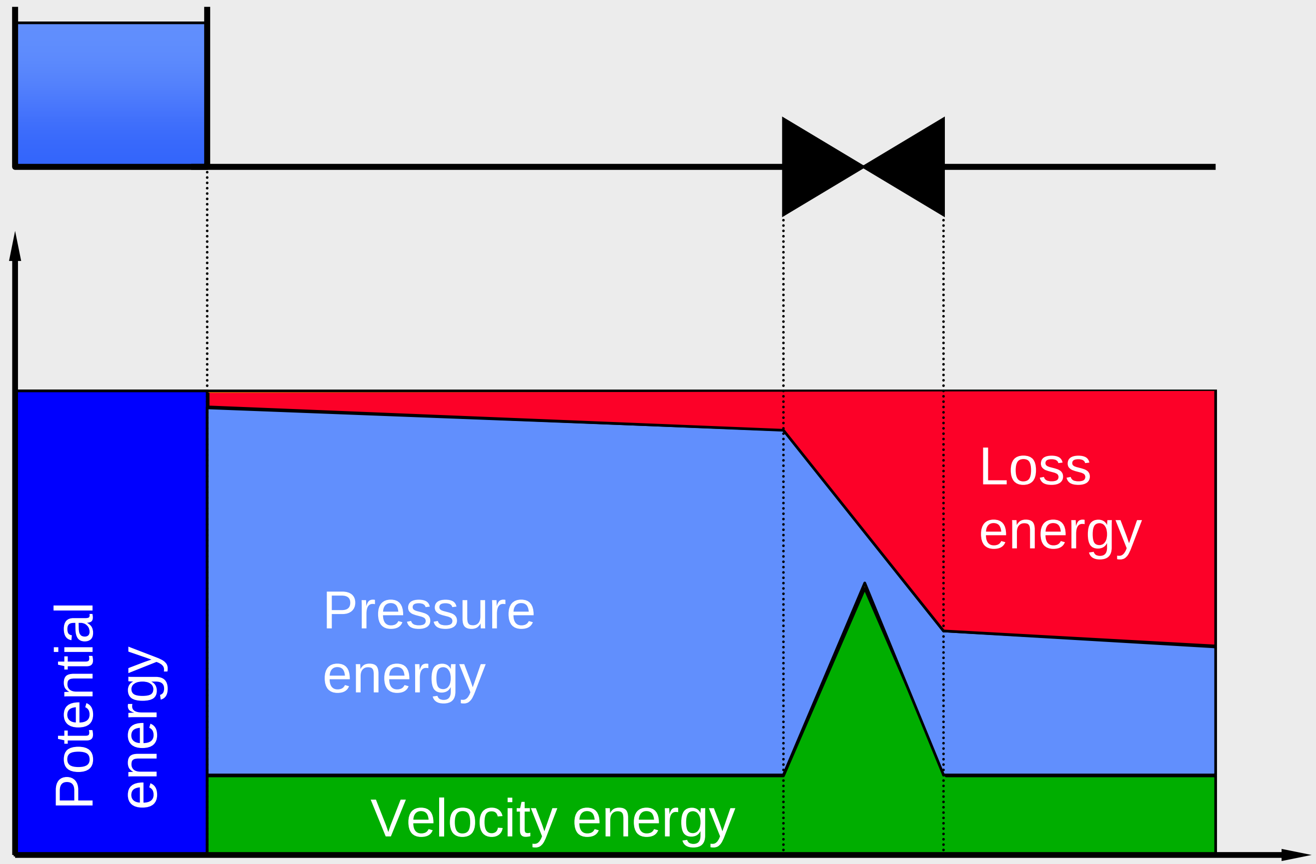
Development of energy types in the plant

In the store reservoir the existing total energy of the static flow is stored as potential energy.

In case of flow through a horizontal pipeline this available potential energy is converted into:

- **velocity energy**
- **pressure energy**
- **loss energy**

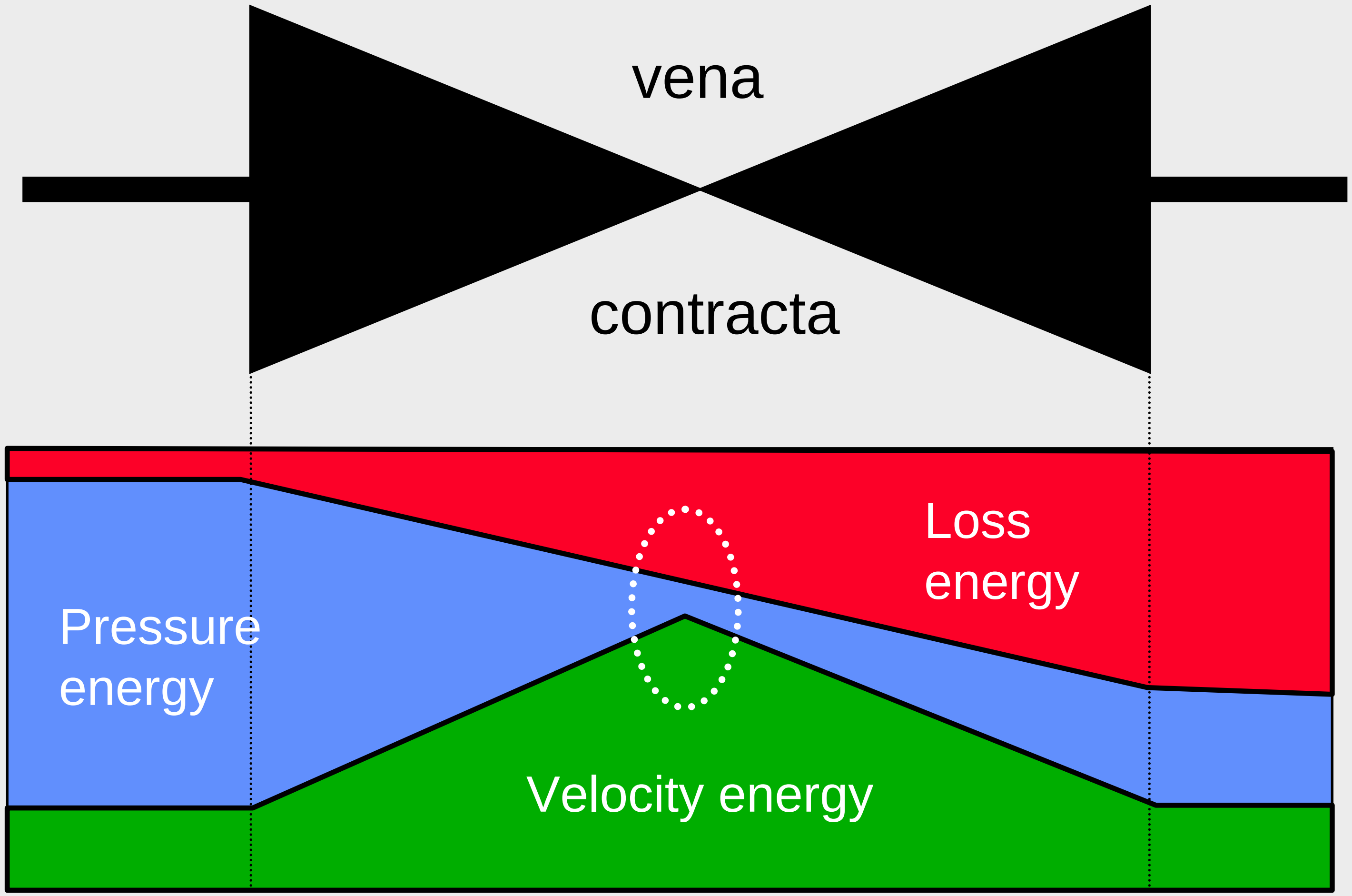


Development of energy types at the throttling point

Due to the contraction of the flow cross section at the throttling point, the flow velocity and thus the corresponding portion of energy rises considerably.

Due to throttling also the number of losses rises considerably.

At the vena contracta the remaining pressure energy and thus the local pressure decrease considerably because of the constancy of the total energy.



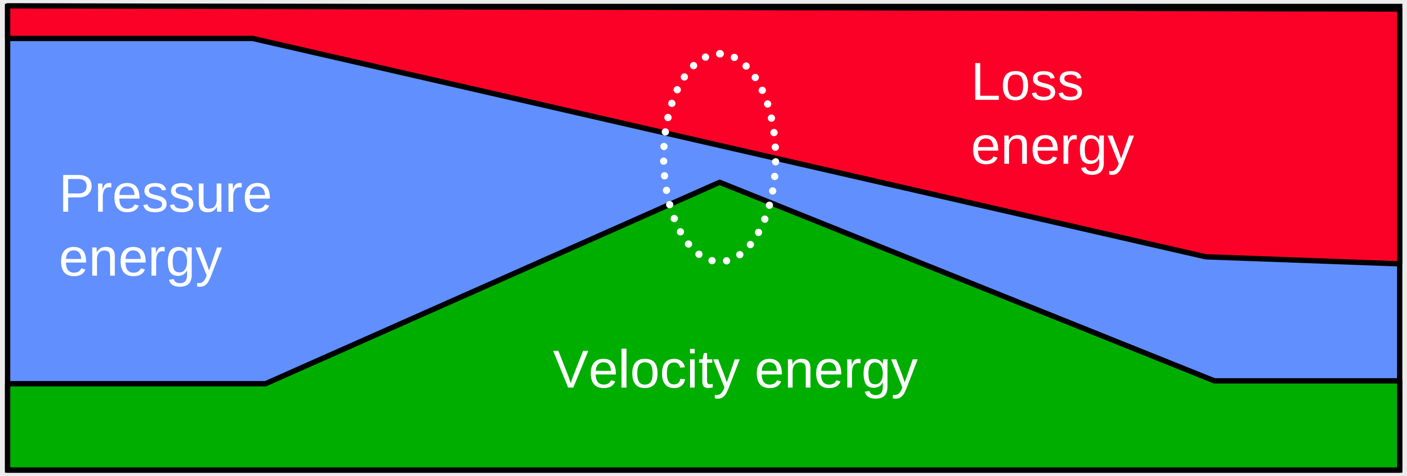
Development of energy types at the throttling point

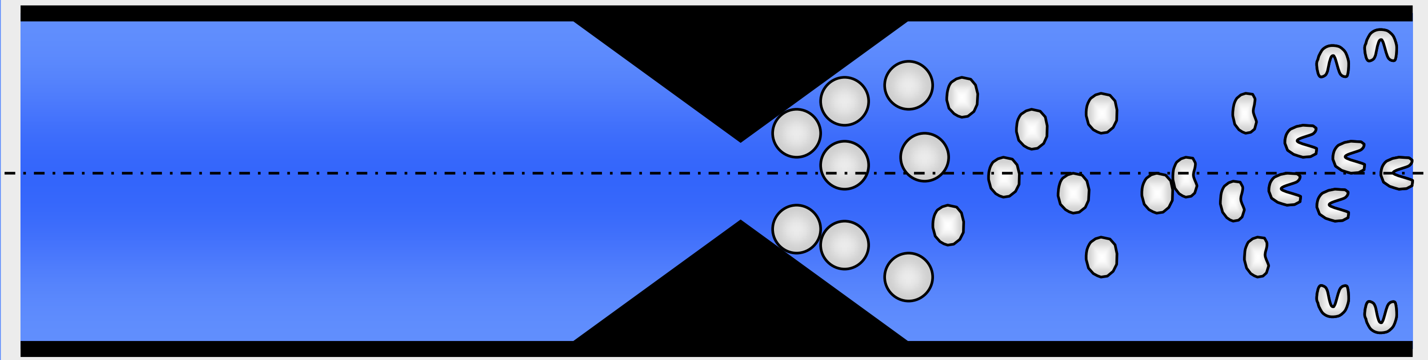
If at this point the water pressure gets lower than the vapour pressure of the medium, it will evaporate.

There will be vapour bubbles, ...

... which are deformed under increasing pressure...

... and will finally implode.



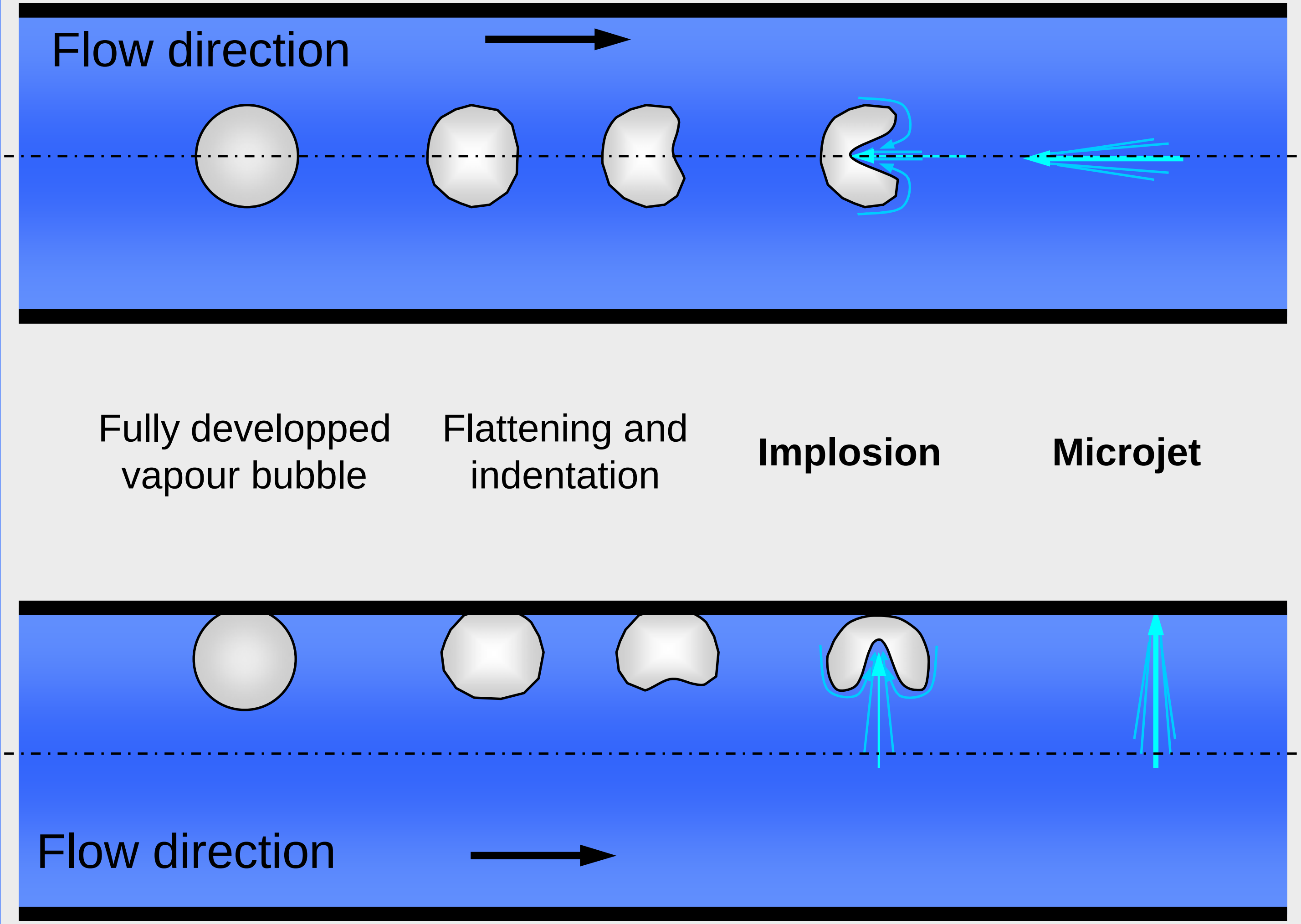


Implosion of the vapour bubbles

The implosion of the vapour bubbles follows certain directions, depending on the pressure conditions:

In the centre of the pipeline

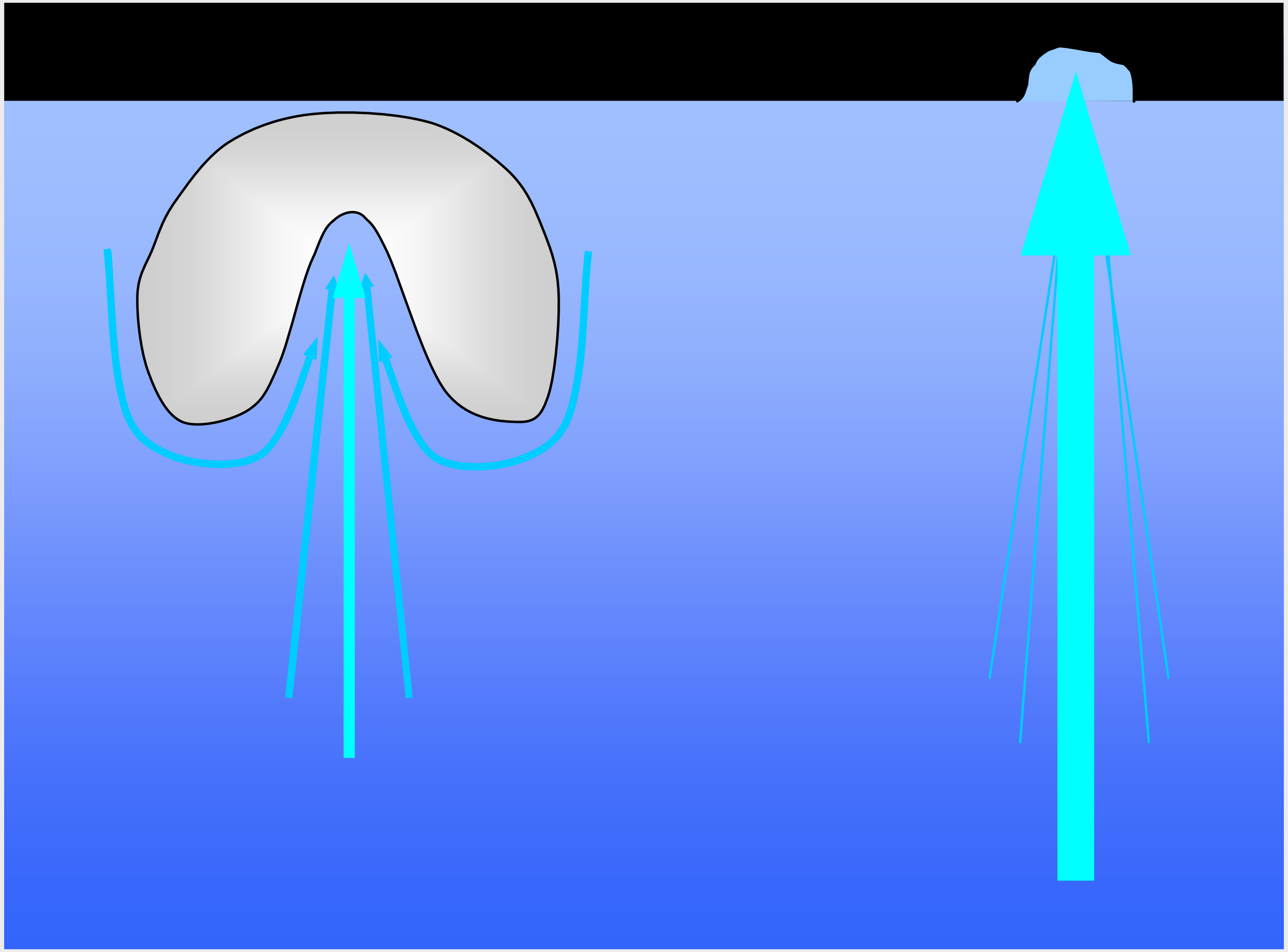
At the pipe wall



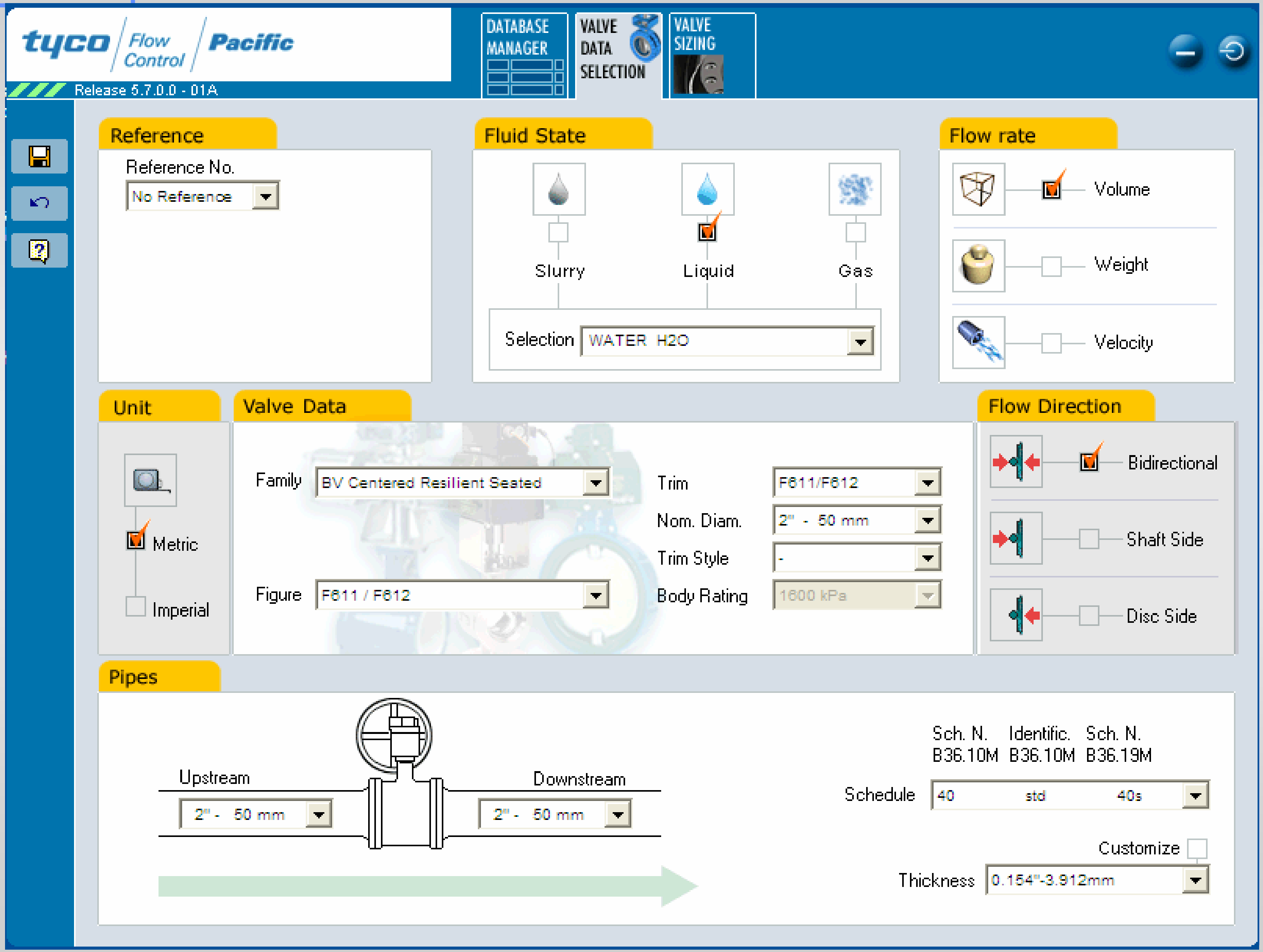
Implosion of the vapour bubbles

As the vapour bubbles suddenly collapse (implode), when changing from vapour into liquid condition, the water surrounding the vapour bubbles is accelerated in inside direction within a split second.

The „Microjet“ resulting thereof hits the wall of the body or pipe at a very high velocity (v>1000 m/s), causing pressure peaks of up to 10000 bars, which erode material in the molecular range.



Cavitation programs



Cavitation calculations