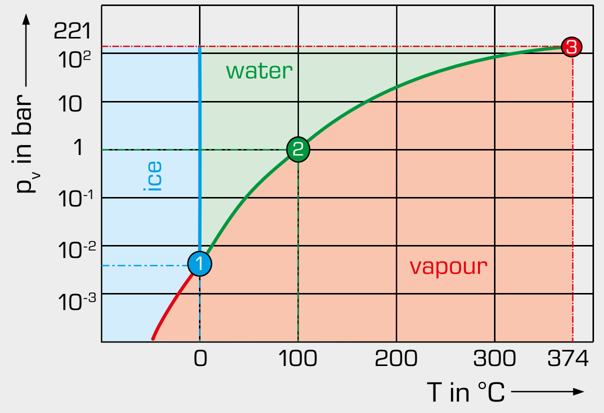
Basic knowledge

Cavitation

When does cavitation occur?

When liquids flow, flow processes may cause local pressures that are smaller than the corresponding vapour pressure of the liquid. In this case, the liquid evaporates and vapour bubbles are formed. The increase in the volume caused by evaporation changes the flow patterns relative to the undisturbed flow. In pumps the vapour bubbles can grow to the extent that the remaining flow cross-section is greatly reduced and the performance of the pump is impaired. The process is often unstable since the flow velocity increases due to the reduction of the flow cross-section and thus cavitation is encouraged by further pressure loss.



Temperature-pressure diagram of water

1 triple point, **2** boiling point, **3** critical point;
sublimation curve, boiling point curve, melting point curve

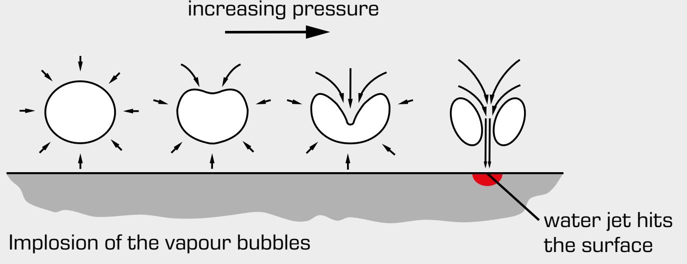
Formation of vapour bubbles due to cavitation at a pump impeller (HM 380)

Machine damage caused by cavitation

Considerable damage is caused by the erosion of the material that occurs in connection with cavitation. When the pressure re-increases the vapour bubbles implode. During the implosion a very rapid liquid jet forms in the vapour bubble, capable of generating pressure of several 1000 bar on impact with a solid material. This erodes the material of propellers, valve plates or impellers. Therefore especially hard and resistant materials must be used in machines subject to damage caused by cavitation.

Cavitation also often results in corrosion. Protective layers are removed and the roughened, porous surface provides ideal conditions for corrosion.

Pump impeller destroyed by cavitation erosion

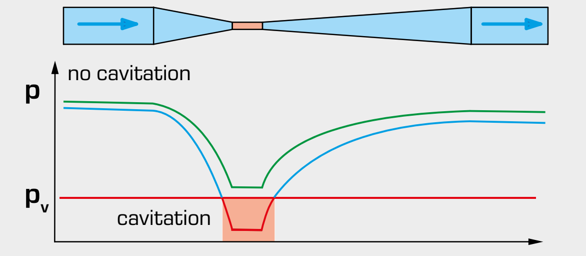


Implosion of the vapour bubbles

Ship's propeller destroyed by cavitation erosion

Artificial generation of cavitation

The occurrence of cavitation can be clearly shown in a Venturi tube, such as GUNT's ST 250 device. The flow is accelerated in the convergent part, thereby reducing the pressure. When the vapour pressure p_v is exceeded, vapour bubbles are formed in the narrowest cross-section. Depending on the intensity, these disappear again in the divergent part or remain for a longer distance.



Cavitation in a Venturi tube

Criteria for the occurrence of cavitation

The criteria for the occurrence of cavitation are mainly the cavitation number and the required net suction head.

The dimensionless **cavitation number σ** is a means for measuring when cavitation occurs in a fluid.

$$\sigma = \frac{p - p_v}{\frac{\rho}{2} \cdot v^2}$$

ρ density, **p** pressure, **p_v** vapour pressure, **v** flow velocity

Another criterion is the NPSH value (Net Positive Suction Head). The NPSH value corresponds to the (pressure) energy of a liquid column under the present operating conditions at the connecting flange. The value is always positive.

A distinction is made between two NPSH values:

NPSHA (Net Positive Suction Head Available): This is the available system pressure at operating conditions as the height difference.

NPSHR (Net Positive Suction Head Required): This is the pressure required for operation of the pump as the height difference.

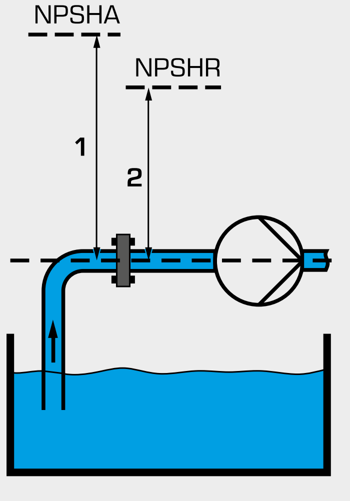
Here, the **system's NPSHA** must always be above the **pump's required NPSHR** value.

Avoiding cavitation

In order to avoid cavitation, the **cavitation number σ** must be kept as high as possible. On the other hand, a small cavitation number results in high energy efficiency and turbomachines with small dimensions.

The following measures reduce the tendency to cavitation:

- avoid low pressures
- avoid temperatures near the fluid's boiling point
- use thin blade profiles
- choose blades with low angle of attack
- avoid abrupt deflections of the flow
- round off the leading edge



Difference between NPSHA (1) and NPSHR (2):

1 pressure energy provided by the system,
2 pressure energy required by the pump