Fundamental Principles for the Project Work and the Operation of EDUR Centrifugal Pump Systems

# 1 Characteristics and Operating Conditions of Radial Type Centrifugal Pumps

## 1. Rate of Flow Q

The transmission flow or the volume flow is the useable liquid volume that exits from the pump's pressure fitting. The base unit is m³/s. Common units are m³/h, l/h and l/min.

## 2. Pump Head H and Head of the System $H_A$

The pump head pressure is calculated from the specific transmission capacity Y Nm/kg, i.e. the energy increase that is realized within the pump with 1 kg of fluid transmission. The specific pump energy Y is determined for the pump in use by measuring and/or calculating the following values: (Fig. 1)

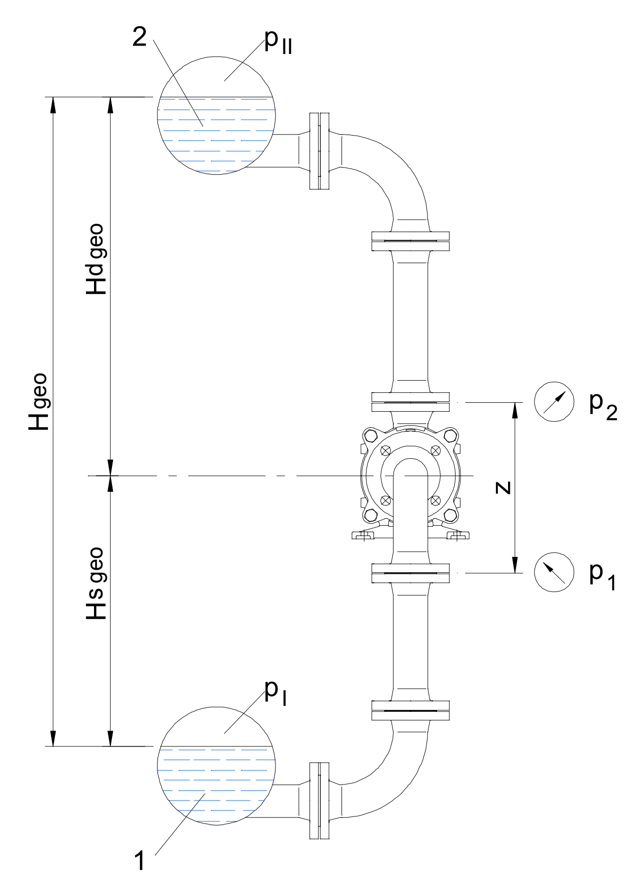

Fig.1 Model for determining the pump head pressure

a) The excess pressure p1 or negative pressure -p1 in the suction fitting in N/m²,
b) the excess pressure p2 in pressure fitting in N/m²,
c) the height difference z of these measure points in m. (This value is positive when the measure point of p2 is higher than that of p1),
d) the kinetic energy of the flow in pressure and suction fitting.

If ρ designates the density of the transmitted liquid in kg/m³, g the local drop acceleration in m/s² and c2 and/or c1 m/s the median speeds in the pipe cross sections of the pressure measurement locations, then the specific pump energy will be equal to:

$$Y = \frac{p_2 - p_1}{\rho} + g \cdot z + \frac{c_2^2 - c_1^2}{2} \qquad \text{Nm/kg} \qquad (1)$$

If one assumes Y to be the potential energy of 1 kg liquid with the weight g N/kg, one can also write:

$$Y = g \cdot H$$

When applying the pressure unit 'bar', the density ρ in kg/dm³ and the drop acceleration g = 9.81 m/s² in the equation (1) will result in pump head pressure:

$$H = \frac{p_2 - p_1}{\rho} \cdot 10{,}2 + z + \frac{c_2^2 - c_1^2}{2 \cdot g} \qquad \text{m} \qquad (2)$$

For an **approximate** determination of the pump head pressure when cold water is pumped, while neglecting the speed-height difference, the following simplified equation can be used:

$$H \approx (p_2 - p_1) \cdot 10 + z \qquad \text{m} \qquad (3)$$

During negative pressure within the suction fitting $p_1$ must be inserted with a negative sign:

For the projection of a pump plant the pump head pressure must be determined in a different manner (pump head pressure $H_A$):

The pump transmits from the suction container 1 (Fig. 1) with the pressure $p_I$ bar into the pressure container 2 with the pressure $p_{II}$ bar. The height difference between suction and water pressure level, the "geodesic pump head pressure" will be $H_{geo}$ m, additionally the sum of all head losses in the suction and pressure line $H_V$ m. (Refer to description regarding "The head loss in pipelines"). Applying the density ρ of the transmitted liquid in kg/dm³ when neglecting the very minimal speeds within the containers will result in the pump pressure head of the plant:

$$H_A = \frac{p_{II} - p_I}{\rho} \cdot 10{,}2 + H_{geo} + H_V \quad \text{m} \qquad (4)$$

The pump must be capable of overcoming both, the head losses $H_V$ within the pipelines and the pump head pressure of the plant.

In the case of negative pressure in the suction container $p_I$ must be inserted with a negative sign. If both containers are open, the following remains:

$$H_A = H_{geo} + H_V \quad \text{m} \qquad (5)$$

$H_V$ not only includes the head losses in the pipelines but also the losses in the connected devices, jets or other pipe attachments

## 3. Efficiency

Only a portion of the energy transmitted from the prime mover to the rotary pump is used for the transmission of the liquid. The rest is absorbed by the losses generated within the pump. These are converted into heat, which is of no value for the generation of pressure and may have a negative effect for the pump.

Pump Power input P, which is necessary for the operation of the pump, is therefore always greater than the available nominal power $P_N$ within the transmitted liquid. The relation

$$\eta = \frac{\text{Nominal Power}}{\text{Pump Power Input}} = \frac{P_N}{P}$$

is the efficiency of the pump. The higher the rate of efficiency, the more economically the pump will operate.

For purposes of the calculation, the power requirement may be taken from the guidelines or performance tables found in the EDUR sales literature. The useful power can be calculated from the following equation:

$$P_N = Q \cdot \rho \cdot g \cdot H = Q \cdot \rho \cdot Y \quad \text{Watt} \qquad (6)$$

Introducing the transmission flow Q in m³/h, the density $\rho$ in kg/dm³ and adding g = 9.81 m/s², results in $P_N$ in kW to:

$$P_N = \frac{Q \cdot H \cdot \rho}{367} \quad \text{kW} \qquad (7)$$