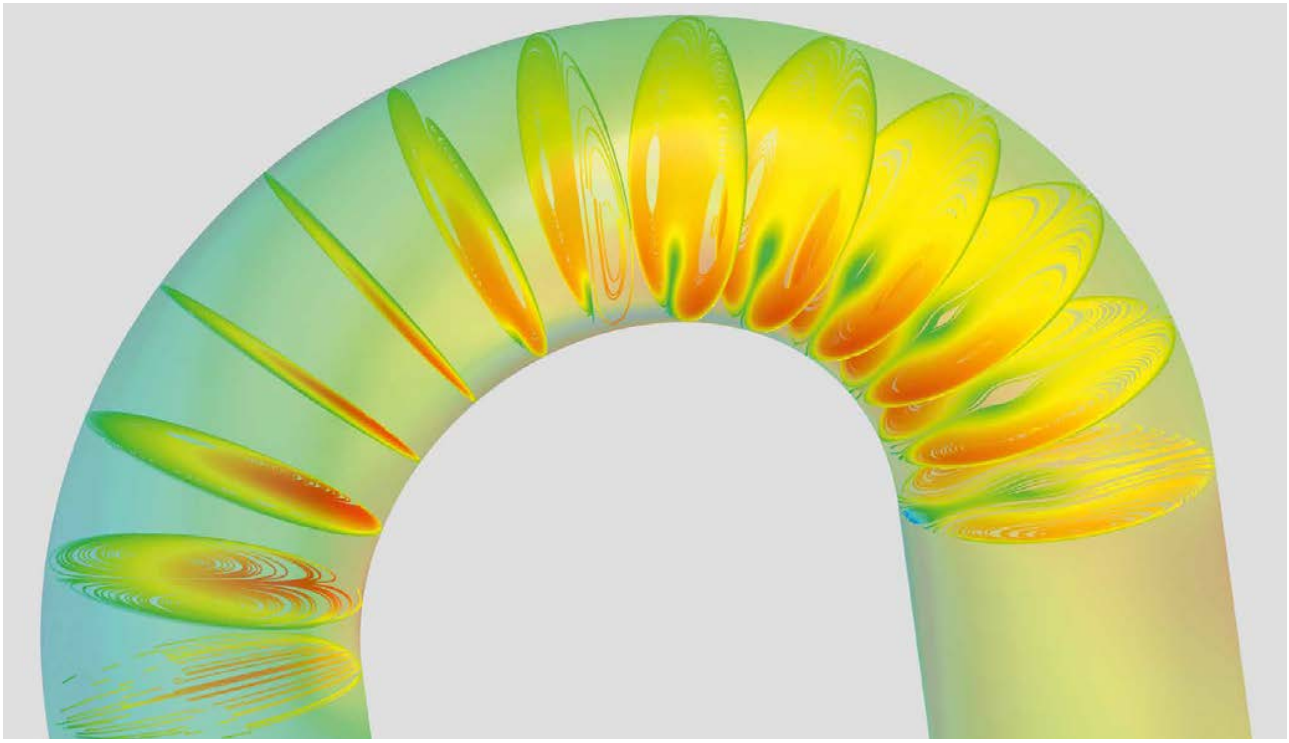
Pressure Drop in Tubular Photobioreactors



Dean-vortex appearance in an U-Bend – computer simulation (ANSYS®CFX® 14.5.7)

For the optimum construction of a photobioreactor the expected pressure loss in the system must be known. This information is relevant for the lay-out of the ideal pump design. For the calculation of the pressure drop of the entire photobioreactor system the pressure drops of the individual components can be added together. The individual pressure drops must be calculated for the desired velocity, *u*.

In the following table (p. 21) the individual pressure drops of representative glass components are shown for a typical flow velocity of 0.7 m/s. The pressure drops depend on the dimensionless zeta-values, which slightly decrease at larger velocities. Please contact SCHOTT technical service for assistance and additional simulations.

Pressure loss

In general, the pressure drop can be calculated for any velocity using the following formula.

$$\Delta p = \zeta \cdot \frac{\rho}{2} \cdot u^2$$

Δp: pressure loss
ζ : pressure loss number (zeta)
ρ: algae culture density
u: linear velocity of algae culture

u = 0.7 m/s	ζ	**Δp [Pa]**
Round Tube (D = 65 mm, WT = 2.2 mm, L = 5.5 m)	1.96	480
U-Bend (D = 65 mm, WT = 2.8 mm)	0.252	62

Pressure drops of a tube and a U-Bend at the given velocity, *u*. D is the outer diameter, WT the wall thickness. The algae culture's density was approximated with ρ=1 g/cm³.

Electrical Power

The electrical power of the pumps, P_{el}, scales with the pressure drop and the volume flow, Q:

$$P_{el} = \frac{\Delta p \cdot Q}{\eta_p}$$

P_{el}: Electrical power
Δp: Sum of pressure loss in Pa
Q: Volume flow rate in m³/s
η_p: Pump efficiency at operating point ($0 < \eta_p < 1$)

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