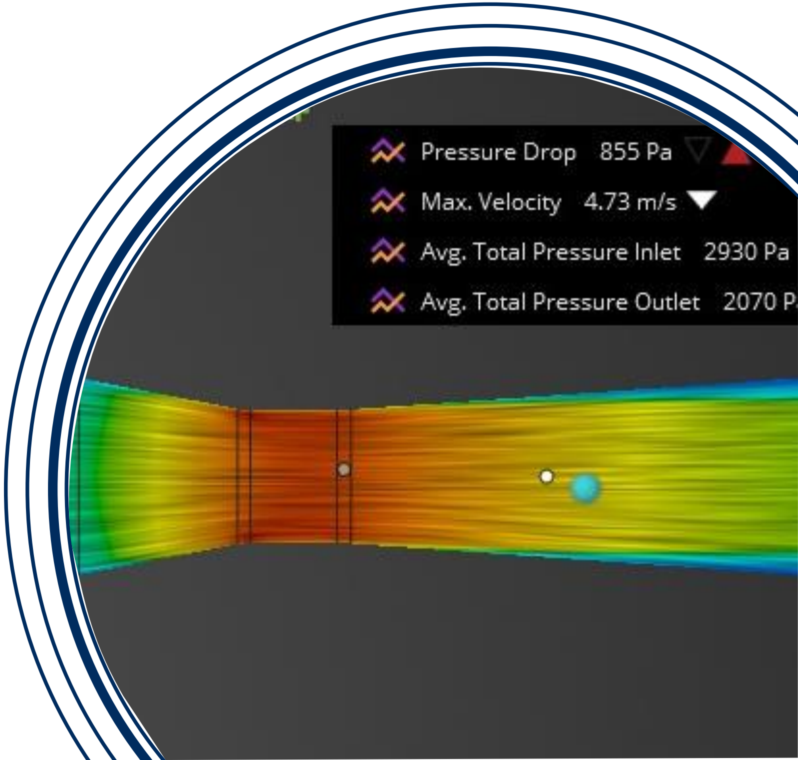
# Understanding different pressure specifications

## Demo M04: Calculating the pressure loss of a venturi pipe

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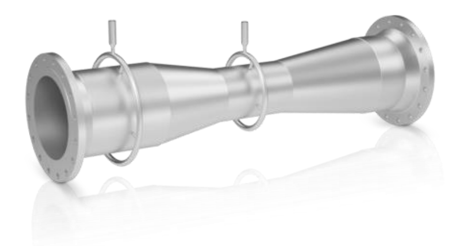
# Understanding different pressure specifications

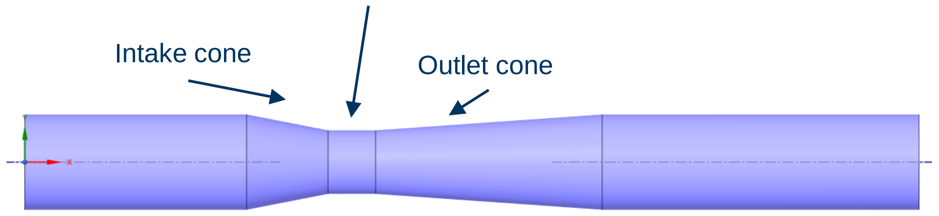
## The Venturi tube

- The classic Venturi tube consists of an inlet cone, a cylindrical neck section and the diffuser.
- Measuring principle
  - The inlet cone causes a narrowing of the pipe → Increasing the velocity and decreasing the static pressure.
  - The differential pressure before and in the cross-sectional reduction can be measured.
  - The diffuser increases the cross-section to the original diameter.



Quelle: https://ch.krohne.com/

- Application area
  - Measurement of contaminated fluids
  - only low pressure losses are allowed
  - Flow measurements with high accuracy



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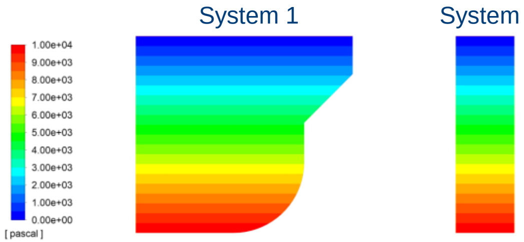
## Pressure specifications

- Static Pressure $p_{stat}$
  Pressure of a moving fluid tangentially to the limiting wall
- Hydrostatic Pressure
  Static pressure of a fluid at rest due to gravity
- Dynamic Pressure $p_{dyn}$
  Kinetic energy per unit volume of a fluid
- Total pressure $p_{tot}$
  Static Pressure + Dynamic Pressure

$$p_{tot} = p_{stat} + p_{dyn} = p_{stat} + \frac{\rho}{2} v^2$$




$p_1 = p_2$

$F = p \cdot A$

$F_1 \neq F_2$

Same hydrostatic pressure in both systems but different resulting force!

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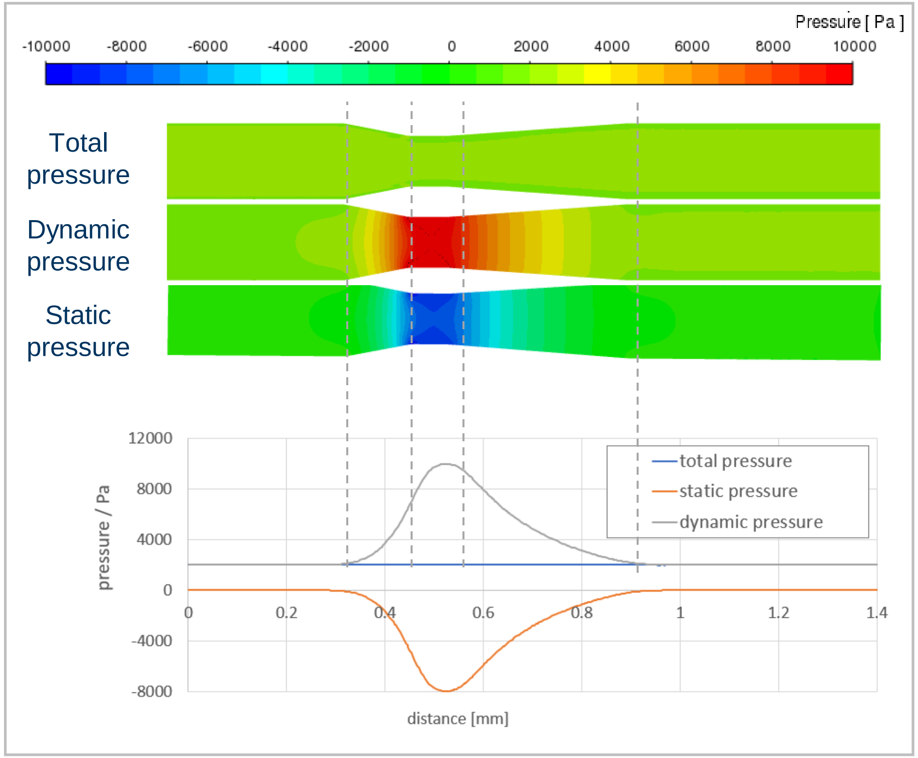
## The Venturi tube – inviscid / frictionless

For a frictionless, inviscid flow Bernoulli's equation is valid :

– The energy / total pressure is conserved

$$p_{total} = p_{dyn} + p_{stat} = \text{const.}$$

- If the velocity in the cross-section constriction increases, the dynamic pressure also increases.
- The static pressure, on the other hand, must decrease so that the total pressure remains constant.



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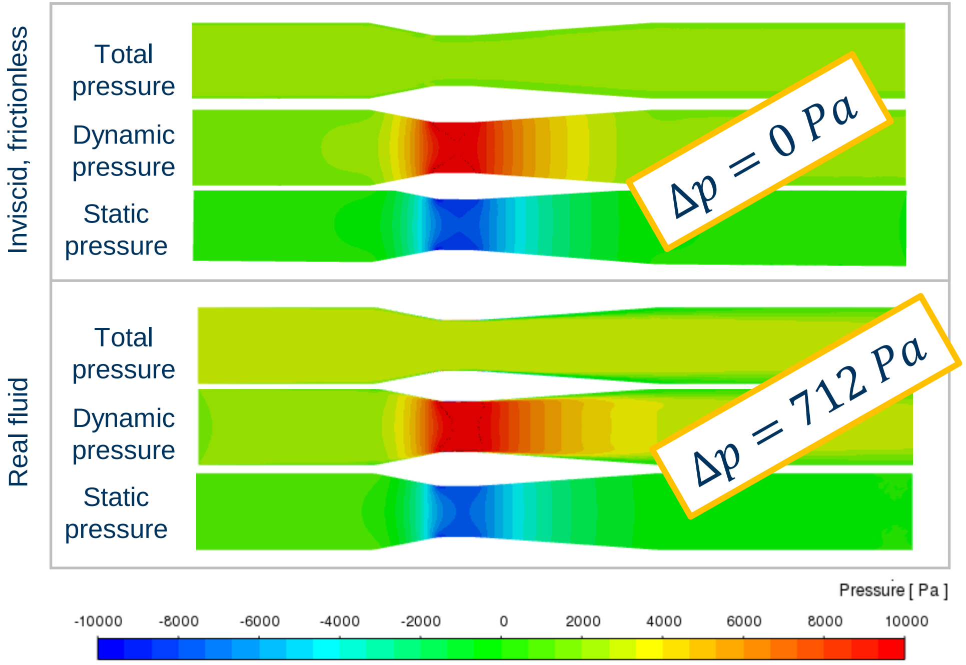
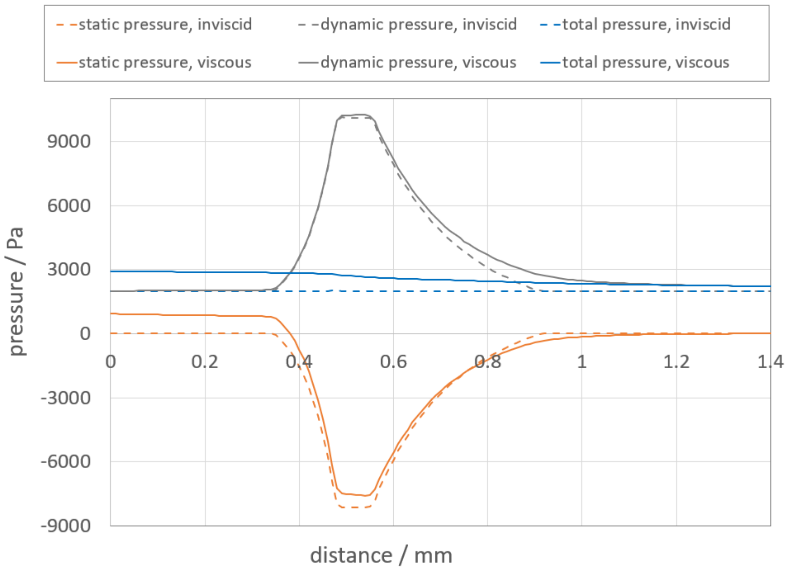
## The Venturi tube – viscous / wall shear

In a real fluid, on the other hand, pressure losses occur and the total pressure no longer remains constant:

$$p_{total,in} = p_{total,out} + \Delta p$$



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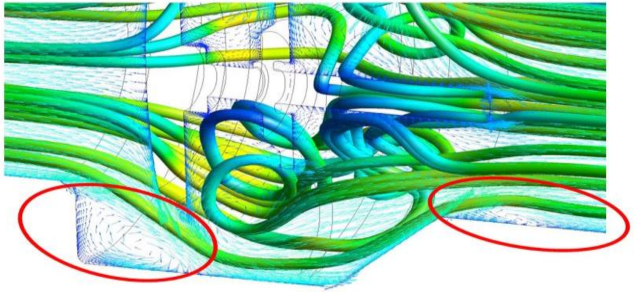
## Reasons for pressure drop

A pressure drop $\Delta p$ can be observed:

$$p_{total,in} = p_{total,out} + \Delta p$$



- Pressure Losses in flowed through systems are caused by
  - Wall friction
  - Viscosity / Turbulence
  - Entry losses
  - Flow detachments / dead zones / recirculations
  - installation of additional components

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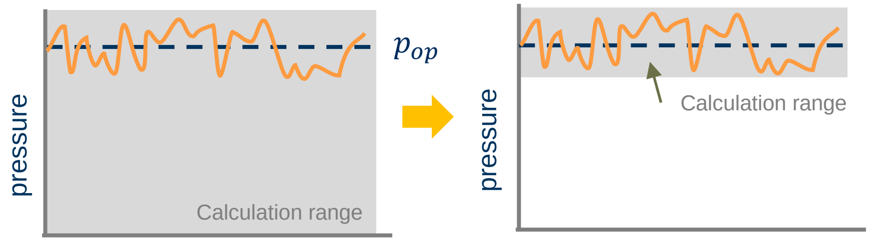
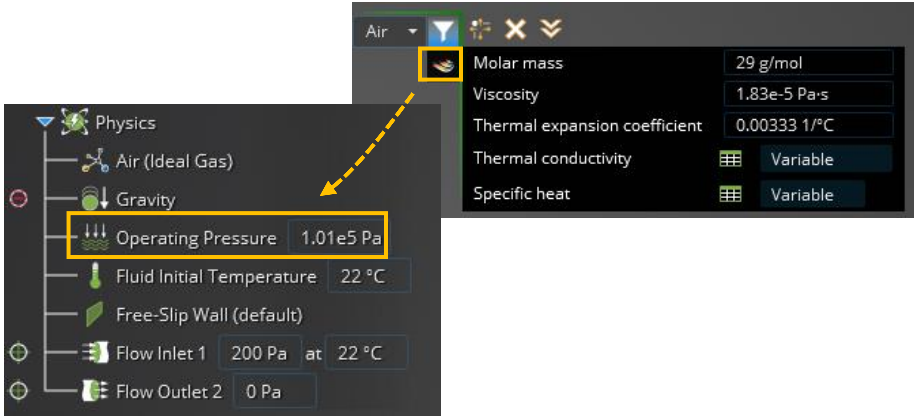
## The gauge and the operating pressure

The absolute pressure is decomposed into an operating value $p_{\text{op}}$ and a gauge value $p_{gauge}$

$$p_{abs} = p_{\text{op}} + p_{gauge}$$
$$\text{with } p_{\text{op}} = 1\ atm$$




- In Discovery we always work with **gauge values**.
- Reason: Reduction of round-off errors when pressure differences in a fluid are small compared to the absolute pressure level
- In **compressible CFD** simulations the operating pressure must be set.
- In **incompressible CFD** simulations the pressure level is not relevant since no flow variables depends on it. Only the gradient is of importance

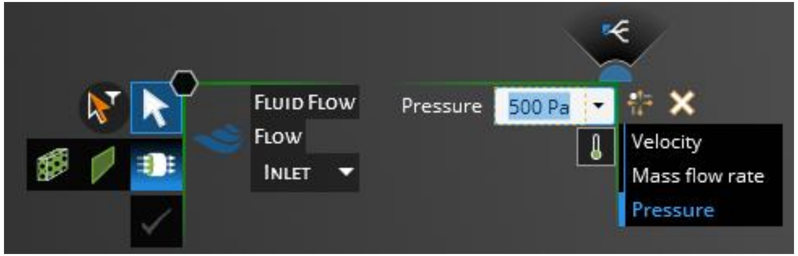


# Understanding different pressure specifications

## Used pressure definitions in Discovery

### Pre-processing

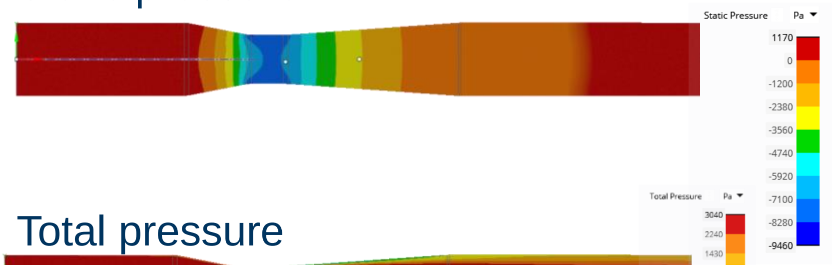
- Flow Inlet: Gauge total pressure



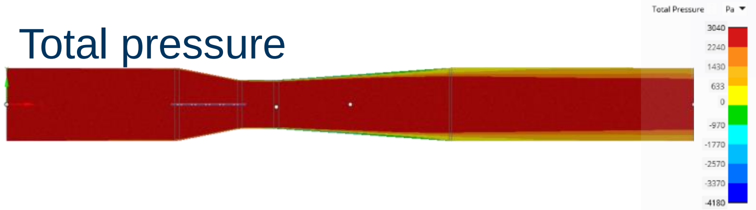

- Flow Outlet: Gauge static pressure


### Post-processing

- Static pressure




- Total pressure




- Pressure Drop is the difference of averaged inlet and outlet total pressures