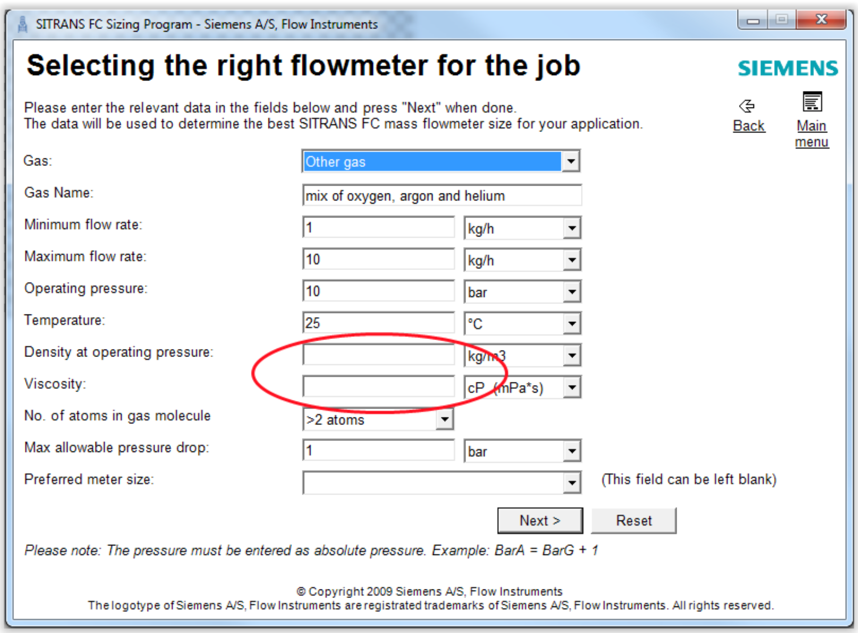
1. Product sizing for gas mixtures

When product sizing for gas mixtures, you need to enter the density and the viscosity for the gas mixture in the sizing tool.



Maybe your customer does not know the values. Then you need to calculate them. The following pages describe how to do this.

2. Average density calculation for gas mixture

The first step is to calculate the average density of the gas mixture. Use the following formula:

$$\rho m = \frac{(\rho 1 v1 + \ \rho 2 v2 + \cdots + \ \rho n v n)}{(v1 + v2 + \cdots \ + vn)}$$

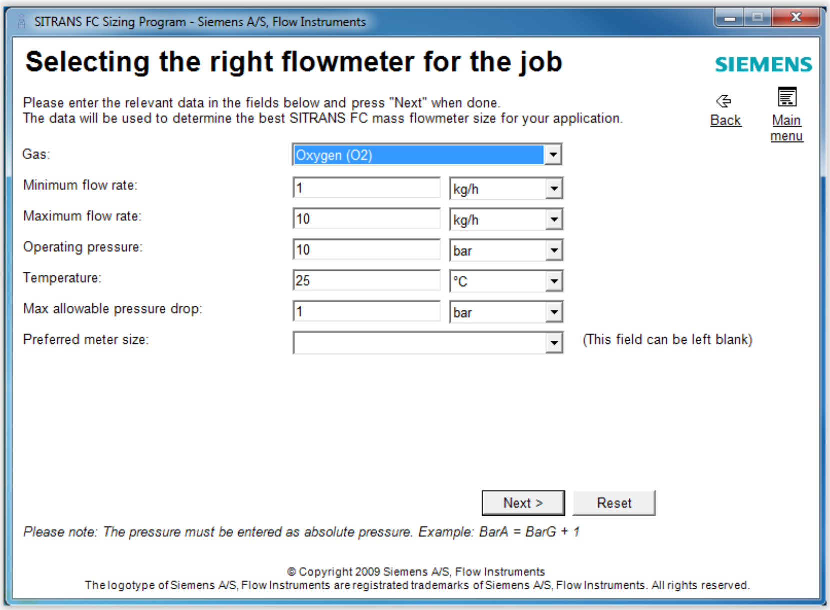
ρm : density of gas mixture at operating conditions

$\rho 1 \ldots \rho n$: densities of the individual gas components at operating conditions

$v1 \ldots vn$: volume share of each gas component (m^3, ft^3 etc.)

Example:

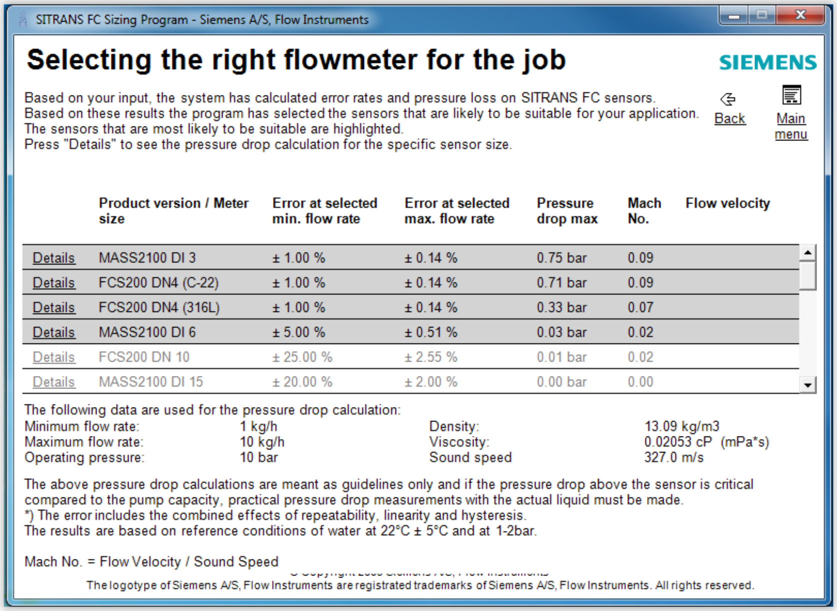
A gas mixture consists of oxygen, argon and helium. They have an equal volume share of 33.3 %. The process pressure is 10 bara and the temperature is 25 °C. With this knowledge you can use the flow sizing tool to calculate the individual gas densities and viscosities at the operating conditions.



The values you enter for min. and max. flow are not important since you are not going to size the flowmeter yet.

Note: The process pressure must be in bara.

Press NEXT to calculate the values for density and viscosity.



Repeat this for helium and argon to end up with the following:

Gas	Density [kg/m^3]	Viscosity [cP]
Oxygen	13.09	0.02053
Helium	1.634	0.01897
Argon	16.33	0.02237

For now you are going to use the densities only. The viscosities must be kept for the viscosity calculation (see 3.).

If you want to end up with the final density unit in kg/m^3, you can in this example assume that each gas has a volume share of 0.333 m^3. The total volume will then be 1 m^3. If you want to have the density in a different unit, e.g. lb/ft^3, you must make a unit conversion.

The average gas density is calculated as follows:

$$\rho m = \frac{(13.09*0.333+16.33*0.333+1.634*0.333)}{(0.333+0.333+0.333)} = \mathbf{10.35}\ \text{kg/m}^3$$

3. Average viscosity calculation for gas mixture

The next step is to calculate the average viscosity of the gas mixture. Use the following formula:

$$\mu = \frac{\sum_{i=1}^{n} ri\mu i\,\sqrt{MiTci}}{\sum_{i=1}^{n} ri\,\sqrt{MiTci}}$$

μ: Dynamic or absolute viscosity of gas mixture

ri : Volume share of component i (in %)

μi : Dynamic or absolute viscosity of component i [1)]

Mi: Molar mass of component i [2)]

Tci: Critical temperature of component i [3)]

[1)]: The value must be calculated at the given process conditions. Use the values you found in the previous step.

[2)]: The molar mass of the specific gas can be found in the table on next page or on the WEB

[3)]: The critical temperature of the specific gas can be found in the table on next page or on the WEB

Example:

To calculate the average viscosity of the previously mentioned gas mixture consisting of 33.3% oxygen, 33.3% helium and 33.3 % argon use the following values. The process pressure is 10 bara and the temperature is 25 °C:

Gas	ri [%]	μi [cP]	Mi [g/mole]	Tci [°K]
Oxygen	33.3	0.02053	32	154.6
Helium	33.3	0.01897	4.003	5.19
Argon	33.3	0.02237	39.94	150.8

The given equation has a numerator and a denominator. Calculate the numerator and the denominator values for each of the gases and then the sum of them. The actual gas viscosity is then finally calculated as the sum of numerators divided by the sum of denominators.

You can use Excel for calculation of the actual gas mixture viscosity.

Process conditions : P = 10 bar abs, t = 25 °C

gas	ri [%]	µi [cP]	Mi [g/mole]	Tci [°K]	numerator ri * ui * sqrt(Mi * Tci)	denominator ri * sqrt(Mi * Tci)
oxygen	33,33	0,02053	32	154,6	48,129	2344,310
helium	33,33	0,01897	4,003	5,19	2,882	151,919
argon	33,33	0,02237	39,94	150,8	57,864	2586,664
			sum of numerators		108,874	
			sum of denominators			5082,893

actual gas viscosity	0,0214	(sum of numerators divided by sum of denominators)

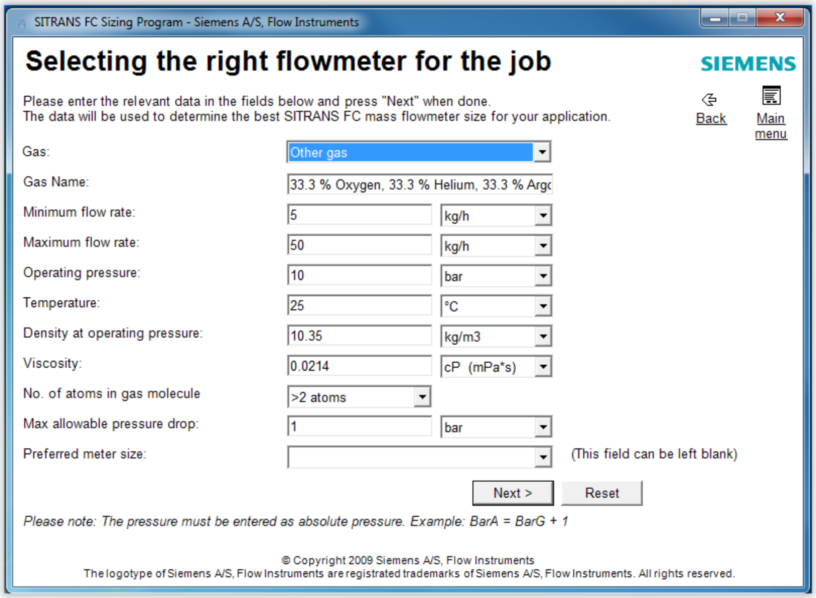
The resulting viscosity for the gas mixture in this example is **0.0214** cP

Constants for some common gases:

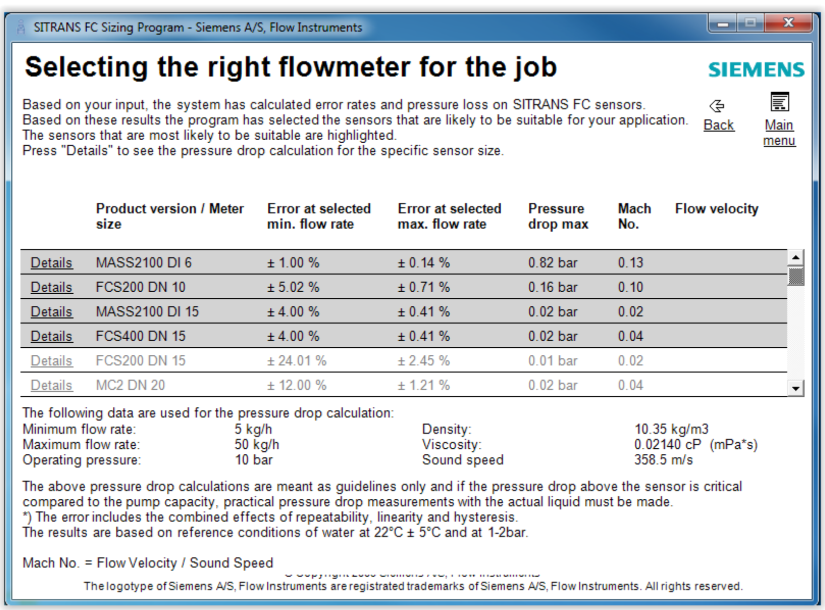
Gas	Molecular weight [g/mole]	Critical temperature [°K]
Argon, Ar	39.94	150.8
Acetylene	26.04	308.36
Ammonia, NH4	17	150.1
Carbon Dioxide, CO2	44.01	304.19
Carbon Monoxide, C0	28.01	132.96
Helium, He	4.003	5.19
Hydrogen, H2	2.016	33.2
Methane, CH4	16.04	190.8
Nitrogen, N2	28.02	126.2
Oxygen, O2	32	154.6
Propane, C3H8	44.09	369.86
Air	28.97	132.45

4. Product sizing

Enter the calculated density and viscosity of the gas mixture in the flow sizing tool to find a flow sensor suitable for the application. Enter the application data including the correct values for minimum and maximum flow.



For gas mixtures the field "No. of atoms in gas molecule" must be ">2 atoms". Click NEXT to see a number of applicable sensors. The flow sensors listed on grey background fit the application best.



The final selection depends on customer requirements such as accuracy, pressure drop, sensor type, sensor cost etc.

The Mach number is an important parameter when measuring gases. The Mach number is the ratio flow speed / gas sound speed, and it must never exceed 0.2 for a given sensor.

Note: The sizing tool does not incorporate the increased sensor non-linearity present when measuring gases. Thus, ± 0.5 % must be added to the listed errors.