12. Category Mixed

12.1. Kinematics

12.1.1. Purpose (What can it be used for? What can it not be used for?)

The program is part of category 7 - mixed. Kinematic sequences can hardly be imagined without observing or watching them. The terms "slow" and "fast" cannot be significant without putting them into a certain relation. Sometimes kinematic calculations can be very helpful for evaluation or review purposes and in order to get an idea about the case-related meaning. To be able to differentiate the types of movement and to evaluate the movement, there are some points to be focused. In the first it is important to get familiar with the coherences between acceleration, speed, distance and time.

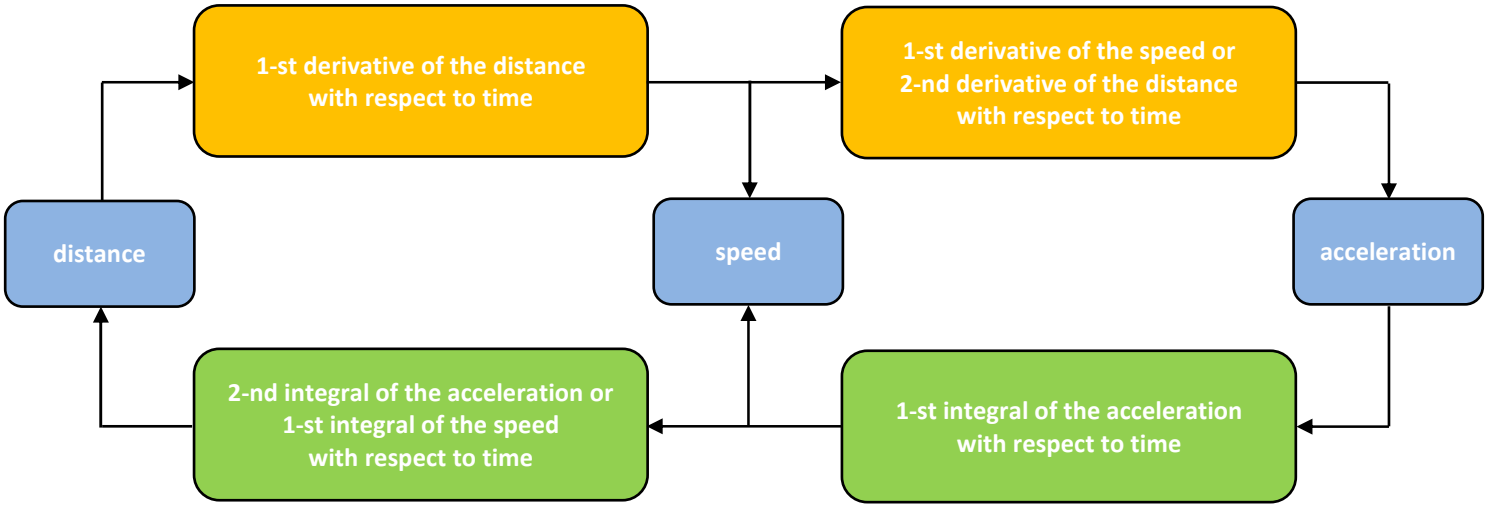


Figure 188: block diagram – coherences between time, distance, speed and acceleration

In general the following questions are mandatory: How far is the distance? Is the movement accelerated or is the speed constant? If the movement is accelerated, is the acceleration constant or not? If the acceleration is not constant, which mathematical function can describe it exactly enough? What is the maximum speed that can be assumed? Are relativistic contemplations required or reasonable?

The program provides calculations for a constant acceleration and calculations for a constant speed, which means the acceleration value is zero. To divide up between these two cases there is a *CheckBox* provided. If this is checked the accelerated movement is considered. Therefore it is assumed that the speed at the beginning of the calculation is zero. If this is not the actual case, the initial speed has finally to be added to the calculated speed. If the accelerated movement is deactivated, a constant speed is assumed, which means at least the value for the acceleration is zero.

The first part of the calculation considers the coherences between acceleration, speed, distance and time. It is possible to choose between an accelerated movement and a movement with a constant speed. If an accelerated movement is considered, the acceleration is the first input variable. One of the variables speed, distance or time can be selected as the second input variable. The residual two will be output variables. If a movement with a constant speed is considered, one of the variables speed, distance or time can be selected as an output variable. The residual two will be input variables.

Taking the mass into consideration as an input variable, the kinetic impulse, which is the product of mass and speed is determined in the second part of the calculation. The propulsive force that results out of the mass and the acceleration is displayed as an output variable only in case if the accelerated movement is activated. Otherwise it is zero according to an acceleration value of zero. Another value that might be of interest regarding kinematic sequences is the kinetic energy where the mass and the square of the speed are relevant.

As auxiliary also relativistic calculations are provided on a separate *TabPage*. All the relativistic calculations are results from the input variables from the first *TabPage*. The relativistic calculations consider the actual speed in relation to the light speed by the relativity factor which is also named "Lorentz-Factor". The impact of this mechanism becomes more and more perceivable if the actual speed gets close to light speed. Under these circumstances the mass increases with respect to the speed. By this also the values for the impulse and the kinetic energy are increasing. At the point where the speed would be equal to the light speed, the denominator of the relativity factor becomes zero. With this the required kinetic energy would tend towards infinity. All relativistic effects calculated by this program are based on homogeneous, not accelerated movements and in direction of the movement, only. For the contemplations two different points of view are relevant: the eye of the beholder, who observes the movement and the eye of the traveler, who is part of the moving system.

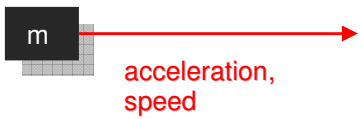


Figure 189: sketch kinematics

12.1.2. Variables (What are the input and output values? What are their limits?)

acceleration

It is the acceleration that the corresponding object is exposed to. The acceleration is the 1-st derivative of the speed or the second derivative of the distance with respect to time. For the provided calculations the acceleration is assumed to be constant. The acceleration can be considered or disregarded by selection.

The variable type is Input.
The unit is meter per second square [m / s^2].
The minimum limit is 0.0001.
The maximum limit is 9999999999.
The replacement value is 1.
The number of digits is 10.

speed

It is the actual speed of the object. The speed is the 1-st derivative of the distance or the 1-st integral of the acceleration with respect to time. The speed is at least a defined distance an object moves or displaces per time unit.

The variable type is Input or Output.
For this variable a selection of different units is provided:

- meter per second [m / s],
- meter per minute [m / min],
- kilometer per hour [km / h],
- kilometer per minute [km / min],
- kilometer per second [km / s].

The minimum limit is 0.0001.
The maximum limit is 9999999999.
The replacement value is 1.
The number of digits is 10.

distance

It is the distance across that the object moves, travels or is displaced measured inside the inertial system. The distance is the 1-st integral of the speed or the 2-nd integral of the acceleration with respect to time.

The variable type is Input or Output.
For this variable a selection of different units is provided:

- Angström [Å],
- nanometer [nm],
- micrometer [µm],
- millimeter [mm],
- centimeter [cm],
- meter [m],
- kilometer [km],
- Astronomic Units [AU],
- lightyear [ly],
- Parsec [Parsec].

The minimum limit is 0.0001.
The maximum limit is 9999999999.
The replacement value is 1.
The number of digits is 10.

time

It is the time that is required to move, travel or displace the object across the corresponding distance. The point of view is the eye of the beholder.

The variable type is Input or Output.
For this variable a selection of different units is provided:

- nanoseconds [ns],
- microseconds [µs],
- milliseconds [ms],
- seconds [s],
- minutes [min],
- hours [h],
- days [days],
- months [months],
- years [years].

The minimum limit is 0.0001.
The maximum limit is 9999999999.
The replacement value is 1.
The number of digits is 10.

mass

It is the mass of the object which is focus for the calculations. The mass is independent from the location. If an object is moving, a value for a relativistic mass can be calculated. It is a measure for the difference between the energies of the moving and the not moving object.

The variable type is Input.
For this variable a selection of different units is provided:

- multiple of the electron mass [me],
- Dalton [u],
- microgram [µg],
- milligram [mg],
- gram [g],
- kilogram [kg],
- tons [tons],
- Megatons [Megatons],
- Gigatons [Gigatons].

The minimum limit is 0.0001.
The maximum limit is 9999999999.
The replacement value is 1.
The number of digits is 10.

impulse

It is the impulse of the object that is focus for the calculations. The impulse is the product of mass and speed of the object.

The variable type is Output.
The unit is kilogram by meter per second [kg m / s].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

propulsive force

It is the force that results from the mass and the acceleration of the object that is focus for the calculations. This variable can be calculated only if the acceleration is considered and if it is greater than zero.

The variable is type Output.
For this variable a selection of different units is provided:

- Newton [N],
- kilo-Newton [kN],
- Mega-Newton [MN],
- Giga-Newton [GN],
- Terra-Newton [TN].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

kin. energy

It is the kinetic energy of the moving object that is focus for the calculations. The kinetic energy results from the mass and the square of its actual speed.

The variable type is Output.
For this variable a selection of different units is provided:

- Joule [J],
- kilo-Joule [kJ],
- Mega-Joule [MJ],
- Giga-Joule [GJ],
- Terra-Joule [TJ].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

relativity factor

It is the relativity factor that has to be taken into consideration whenever something is moving so fast that its speed gets close to light speed which is approximately 300000 km / s. In this case relativistic calculations are done where the relativity factor is used for determination of the values. The relativity factor is also known as "Lorentz-Factor".

The variable type is Output.
The variable has no unit [-].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

speed

It is the speed of the object. The speed is the 1-st derivative of the distance or the 1-st integral of the acceleration with respect to time. The speed is at least a defined distance an object moves or displaces per time unit.

The variable type is Output.
For this variable a selection of different units is provided:

- meter per second [m / s],
- meter per minute [m / min],
- kilometer per hour [km / h],
- kilometer per minute [km / min],
- kilometer per second [km / s].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

distance*

It is the distance across that the object moves, travels or is displaced where the Lorentz-Factor is considered. It is the distance measured from outside the inertial system. The distance is the 1-st integral of the speed or the 2-nd integral of the acceleration with respect to time.

The variable type is Output.
For this variable a selection of different units is provided:

- Angström [Å],
- nanometer [nm],
- micrometer [µm],
- millimeter [mm],
- centimeter [cm],
- meter [m],
- kilometer [km],
- Astronomic Units [AU],
- lightyear [ly],
- Parsec [Parsec].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

time*

It is the relativistic time that is required to move, travel or displace the object across the corresponding distance where the Lorentz-Factor is considered. The point of view is the eye of the traveler.

The variable type is Output.
For this variable a selection of different units is provided:

- nanoseconds [ns],
- microseconds [µs],
- milliseconds [ms],
- seconds [s],
- minutes [min],
- hours [h],
- days [days],
- months [months],
- years [years].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

mass*

It is the mass of the moving object which is focus for the calculations where the Lorentz-Factor is considered. The mass is independent from the location. If an object is moving, a value for a relative mass can be calculated. It is a measure for the difference between the energies of the moving and the not moving object.

The variable type is Output.
For this variable a selection of different units is provided:

- multiple of the electron mass [me (el. mass)],
- Dalton [u (Dalton)],
- microgram [µg],
- milligram [mg],
- gram [g],
- kilogram [kg],
- tons [tons],
- Megatons [Megatons],
- Gigatons [Gigatons].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

impulse*

It is the impulse of the object that is focus for the calculations where the Lorentz-Factor is considered. The impulse is the product of mass and speed of the object.

The variable type is Output.
The unit is kilogram by meter per second [kg m / s].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

propulsive force*

It is the force that results from the mass and the acceleration of the object that is focus for the calculations where the Lorentz-Factor is considered. This variable can be calculated only if the acceleration is considered and if it is greater than zero.

The variable is type Output.
For this variable a selection of different units is provided:

- Newton [N],
- kilo-Newton [kN],
- Mega-Newton [MN],
- Giga-Newton [GN],
- Terra-Newton [TN].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

kin. energy*

It is the kinetic energy of the moving object that is focus for the calculations where the Lorentz-Factor is considered. The kinetic energy results from the mass and the square of its actual speed.

The variable type is Output.
For this variable a selection of different units is provided:

- Joule [J],
- kilo-Joule [kJ],
- Mega-Joule [MJ],
- Giga-Joule [GJ],
- Terra-Joule [TJ].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

12.1.3. Operation (How can it be used? How to proceed?)

Step 1:
Consider acceleration
I can select if the movement is assumed to be accelerated or not. In case of an accelerated movement, the acceleration is assumed to be constant.

Step 2:
Select the variable to be calculated
By clicking on the corresponding *RadioButton* I can choose the variable to be calculated. It is like executing an internal conversion of the equation.

Step 3:
Fill the Input-*TextBoxes*
I enter the values for the input variables. I should respect the variable limits and take care that the entered values are numeric.

Step 7:
Check result
After clicking the Calculate-Button I can check the result.

Step 4:
Units
There is a choice of different units for each variable.

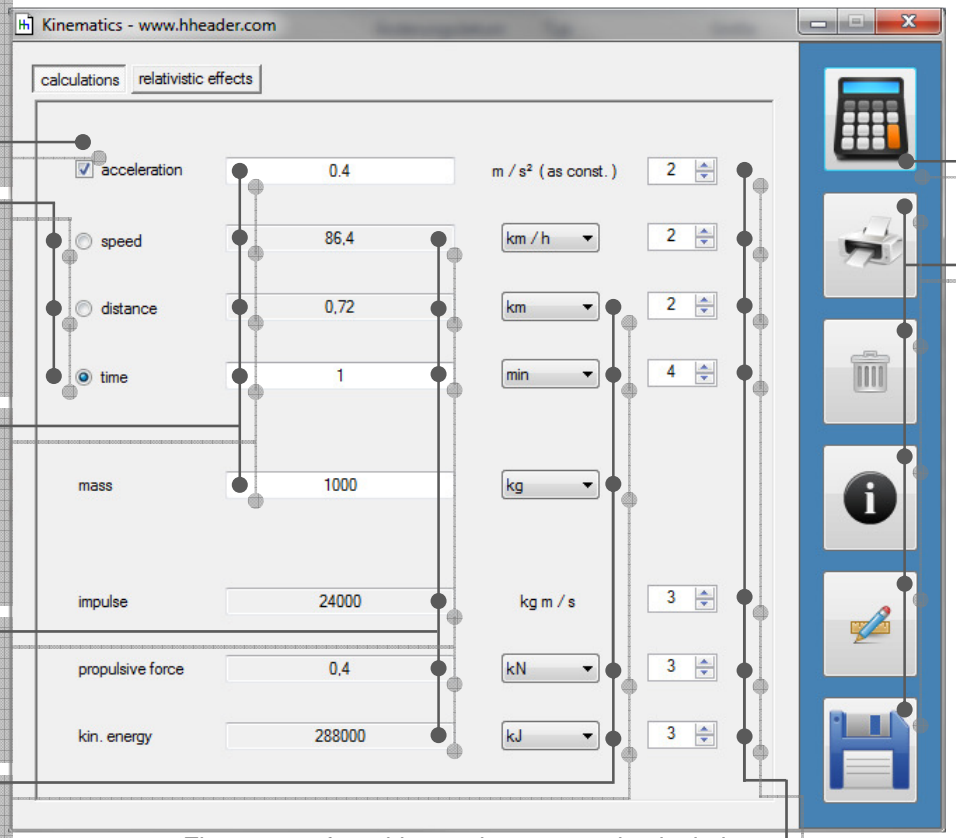


Figure 190: form kinematics – normal calculations

Step 6:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 8:
Further actions
After the calculation I can have the following options: Print Data, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

Step 5:
Enter the number of decimal places
I enter the number of decimal places for the variables. It is valid only if the corresponding variable is selected as output. The input variables can get more or less decimal numbers according to the number of digits.

Step 7:
Check result
After clicking the Calculate-Button I can check the result.

Step 4:
Units
There is a choice of different units for each variable. After changing the unit a calculation will be executed automatically.

Step 5:
Enter the number of decimal places
I enter the number of decimal places for the variables. It is valid only if the corresponding variable is selected as output. The input variables can get more or less decimal numbers according to the number of digits.

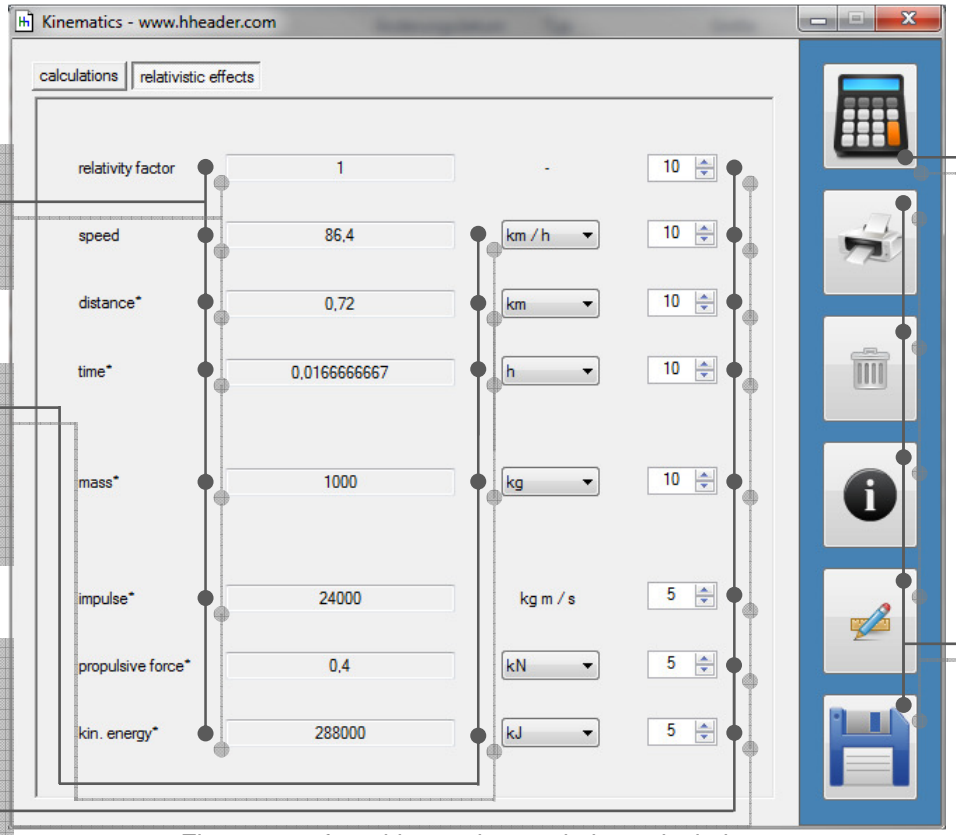


Figure 191: form kinematics – relative calculations

Step 6:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 8:
Further actions
After the calculation I can have the following options: Print Data, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

12.2. Steam Table

12.2.1. Purpose (What can it be used for? What can it not be used for?)

The program is part of category 7 – mixed. The program and the provided calculations refer to water vapor, only. Generally steam can occur either if liquid evaporates or solid sublimates. During sublimation the transition from the solid to the gaseous phase takes place directly without the appearance of the liquid phase. The evaporation behavior of water depends mainly on two parameters which are temperature and pressure. While there are no further outer influences temperature and pressure are directly in coherence to each other.

Beside this the following variables are relevant: the specific volume, the intrinsic energy, the enthalpy and the entropy. Therefore each of these variables appears twice in order to divide up between the liquid respectively the solid phase and the gaseous phase. The variables for the liquid respectively the solid phase are marked with a single quote (‘) and the variables for the gaseous phase are marked with a double quote (“). For the energies, which are the intrinsic energy, the enthalpy and the entropy also the delta values (differences between the liquid and the gaseous phase) are calculated. The mentioned variables are defined and further explained in the next chapter:

- range (temperature range),
- temperature,
- pressure,
- spec. volume v’,
- spec. volume v”,
- intrinsic energy u’,
- intrinsic energy u”,
- delta intrinsic energy,
- enthalpy h’,
- enthalpy h”,
- delta enthalpy,
- entropy s’,
- entropy s”,
- delta entropy.

Regarding the evaporation behavior of water different cases have to be divided up. Depending on the case and the given input parameters there are corresponding temperature ranges defining the limits of the cases. The following cases are selectable for the corresponding calculations:

- Temp. – saturated,
- Pressure – saturated,
- Temp. – sublimated,
- Superheated Steam,
- Supercooled Liquid.

In the following the different cases are explained more detailed in order to give an overview about their purposes and the corresponding background circumstances.

Temp. – saturated: temperature table for saturated steam

The table considers the case of saturated steam. The temperature has to be entered as a given variable and the corresponding pressure will be calculated beside the specific volume, the intrinsic energy, the enthalpy and the entropy. Therefore each of these variables appears twice in order to divide up between the liquid phase and the gaseous phase. The variables for the liquid phase are marked with a single quote (‘) and the variables for the gaseous phase are marked with a double quote (“). For the energies, which are the intrinsic energy, the enthalpy and the entropy also the delta values (differences between the liquid and the gaseous phase) are calculated. For the saturated steam both, liquid and gaseous phase can occur. At least the temperature table and the pressure table are working in reverse to each other regarding the input and output parameters. The temperature range provided for the calculations is from 0.01 °C to 374.14 °C which equates to a pressure range from 0.006113 bar to 220.9 bar.

Pressure. – saturated: pressure table for saturated steam

The table considers the case of saturated steam. The pressure has to be entered as a given variable and the corresponding temperature will be calculated beside the specific volume, the intrinsic energy, the enthalpy and the entropy. Therefore each of these variables appears twice in order to divide up between the liquid phase and the gaseous phase. The variables for the liquid phase are marked with a single quote (‘) and the variables for the gaseous phase are marked with a double quote (“). For the energies, which are the intrinsic energy, the enthalpy and the entropy also the delta values (differences between the liquid and the gaseous phase) are calculated. For the saturated steam both, liquid and gaseous phase can occur. At least the pressure table and the temperature table are working in reverse to each other regarding the input and output parameters. The pressure range provided for the calculations is from 0.006113 bar to 220.9 bar which equates to a temperature range from 0.01 °C to 374.14 °C.

Temp. – sublimated: temperature table for sublimated steam

The table considers the case of sublimated steam. During sublimation the transition from the solid to the gaseous phase takes place directly without the appearance of the liquid phase. The temperature has to be entered as a given variable and the corresponding pressure will be calculated beside the specific volume, the intrinsic energy, the enthalpy and the entropy. Therefore each of these variables appears twice in order to divide up between the solid phase and the gaseous phase. The variables for the solid phase are marked with a single quote (‘) and the variables for the gaseous phase are marked with a double quote (“). For the energies, which are the intrinsic energy, the enthalpy and the entropy also the delta values (differences between the solid and the gaseous phase) are calculated. For the saturated steam both, solid and gaseous phase can occur. The temperature range provided for the calculations is from -40 °C to 0.01 °C which equates to a pressure range from 0.000129 bar to 0.006113 bar.

Superheated Steam: temperature and pressure for steam with increased temperature

The table considers the case of superheated steam. In this case the temperature of the steam is above the saturation temperature. Temperature and pressure have to be entered as given variables and the corresponding specific volume and the energy values will be calculated. It is obvious, that for this case only the gaseous phase can be relevant. This is why only the values for the gaseous phase marked with a double quote (") are displayed. For the superheated steam only the gaseous phase can occur.

Internally the table provides calculations for predefined operation pressure values. The operation pressure values for the superheated steam can be selected via a corresponding *ComboBox*. The temperature ranges are accordingly. The following selections are possible:

No.	Pressure	Temperature Range
1	0.1 bar	45.81 °C > T > 1000 °C
2	0.5 bar	81.33 °C > T > 1000 °C
3	1 bar	99.63 °C > T > 1000 °C
4	2 bar	120.23 °C > T > 1000 °C
5	3 bar	133.55 °C > T > 1000 °C
6	4 bar	143.63 °C > T > 1000 °C
7	5 bar	151.86 °C > T > 1000 °C
8	6 bar	158.85 °C > T > 1000 °C
9	8 bar	170.34 °C > T > 1000 °C
10	10 bar	179.91 °C > T > 1000 °C
11	12 bar	187.99 °C > T > 1000 °C
12	14 bar	195.07 °C > T > 1000 °C
13	16 bar	201.41 °C > T > 1000 °C
14	18 bar	207.15 °C > T > 1000 °C
15	20 bar	212.42 °C > T > 1000 °C
16	25 bar	223.99 °C > T > 1000 °C
17	30 bar	233.90 °C > T > 1000 °C
18	35 bar	242.60 °C > T > 1000 °C

No.	Pressure	Temperature Range
19	40 bar	250.40 °C > T > 1000 °C
20	45 bar	257.49 °C > T > 1000 °C
21	50 bar	263.99 °C > T > 1000 °C
22	60 bar	275.64 °C > T > 1000 °C
23	70 bar	285.88 °C > T > 1000 °C
24	80 bar	295.06 °C > T > 1000 °C
25	90 bar	303.40 °C > T > 1000 °C
26	100 bar	311.06 °C > T > 1000 °C
27	125 bar	327.89 °C > T > 1000 °C
28	150 bar	342.24 °C > T > 1000 °C
29	175 bar	354.75 °C > T > 1000 °C
30	200 bar	365.81 °C > T > 1000 °C
31	250 bar	375 °C > T > 1000 °C
32	300 bar	375 °C > T > 1000 °C
33	350 bar	375 °C > T > 1000 °C
34	400 bar	375 °C > T > 1000 °C
35	500 bar	375 °C > T > 1000 °C
36	600 bar	375 °C > T > 1000 °C

Supercooled Liquid: temperature and pressure for liquid (steam) with decreased temperature

The table considers the case of supercooled liquid. In this case the temperature of the steam is below the saturation temperature. Temperature and pressure have to be entered as a given variables and the corresponding specific volume and the energy values will be calculated. It is obvious, that for this case only the liquid phase can be relevant. This is why only the values for the liquid phase with a single quote (‘) are displayed. For the supercooled liquid only the liquid phase can occur.

Internally the table provides calculations for predefined operation pressure values. The operation pressure values for the supercooled liquid can be selected via a corresponding *ComboBox*. The temperature ranges are accordingly. The following selections are possible:

No.	Pressure	Temperature Range
1	50 bar	0 °C > T > 263.99 °C
2	100 bar	0 °C > T > 311.06 °C
3	150 bar	0 °C > T > 342.24 °C

No.	Pressure	Temperature Range
4	200 bar	0 °C > T > 365.81 °C
5	300 bar	0 °C > T > 380 °C
6	500 bar	0 °C > T > 380 °C

Note:
The provided table values have been entered and stored manually inside an internal data base. The values in between the given interpolation points are calculated by linear interpolation. No approximate equations have been used, because they do not work exactly for the total temperature range.

The program gives back the relevant values for the specific volume and the energies (intrinsic energy, enthalpy and entropy) for a duty point that is defined by the circumstances for the steam (saturated, superheated or supercooled) and the corresponding temperature, respectively pressure values. The values can be determined for two separate duty points in order to compare their energy values. The resulting differential energies can be used for evaluation of the energy balance for a steam system like an industrial boiler for example.

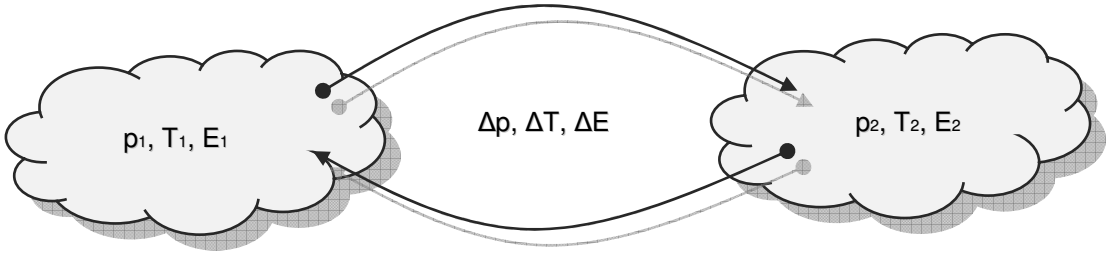


Figure 192: sketch steam table

Terms of pressure

Handling the steam table requires to be familiar with some different terms of pressure. The following descriptions should give an adequate overview regarding the use of the programs.

zero pressure (vacuum)

The zero pressure (vacuum) is the pressure in a physically perfect vacuum (empty space, e.g. outer space). The theoretical value is zero bar. It is the reference value for the absolute pressure value.

zero pressure altitude

The zero pressure altitude is the altitude measured from the earth surface, where the pressure is almost equal the zero pressure (vacuum). This is approximately 100 km above the mean-sea level (Kármán-Line).

atmospheric pressure

The atmospheric pressure is an external pressure, which is affected by many different and various parameters (weather, altitude, etc.). The atmospheric pressure is changing continuously and is never constant.

ambient pressure

The ambient pressure is the external pressure at a defined location. In most cases this is equal to the atmospheric pressure as long as rooms are not pressure-capsulated. The ambient pressure can also be artificially induced e.g. in a pressure chamber.

standard pressure

The standard pressure is a reference point for many physically and technically procedures (1013.25 mbar absolute). It is the value of the assumed atmospheric pressure at the mean sea-level on earth.

differential pressure

The differential pressure is the difference between two pressure levels ($\Delta p = p1 - p2$). Pressure measuring can only take place to a reference pressure level.

gauge pressure

The gauge pressure is the measured differential pressure to the surrounding ambient pressure. It is a relative pressure. Pressure measuring can only take place to a reference pressure level.

absolute pressure

The absolute pressure is the differential pressure to the zero pressure of a physically perfect vacuum.

Relations

+ generally	The absolute pressure value is equal to gauge pressure value plus the atmospheric pressure value.	$p_{abs} = p_{gauge} + p_{atm}$
+ practically	The absolute pressure value is equal to gauge pressure value plus the standard pressure value of 1013.25 mbar (location earth, mean see level).	$p_{abs} = p_{gauge} + p_{sta}$

12.2.2. Variables (What are the input and output values? What are their limits?)

range

It is the temperature range for the selected case. For each table selection there is a certain temperature range defined. The lower limit and the upper limit of the range are equal to the minimum and the maximum limits for the temperature input variables. For each temperature value there is a corresponding pressure value. Thereby the limits for the pressure input values are also defined. So that the temperature and pressure input limits are dynamic and depend on the table selection.

The variable type is Output.
The unit is degree Celsius [°C].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

temperature

It is the temperature for the focused case that is according to the selected table. The lower limit and the upper limit of the range are equal to the minimum and the maximum limits for the temperature input variables. For each temperature value there is a corresponding pressure value. Thereby the limits for the pressure input values are also defined. So that the temperature and pressure input limits are dynamic and depend on the table selection.

The variable type is Input or Output.
The unit is degree Celsius [°C].
The minimum limit is dynamic and set due to the table selection.
The maximum limit is dynamic and set due to the table selection.
The replacement value is equal to the minimum limit.
The number of digits is 10.

pressure (abs.)

It is the absolute pressure for the focused case that is according to the selected table. The lower limit and the upper limit of the range are equal to the minimum and the maximum limits for the temperature input variables. For each temperature value there is a corresponding pressure value. Thereby the limits for the pressure input values are also defined. So that the temperature and pressure input limits are dynamic and depend on the table selection.

The variable type is Input or Output.
The unit is bar [bar].
The minimum limit is dynamic and set due to the table selection.
The maximum limit is dynamic and set due to the table selection.
The replacement value is equal to the minimum limit.
The number of digits is 10.

spec. volume v'

It is the specific volume for the liquid phase (solid phase only while sublimation), which is the volume that is occupied per kilogram. It is at least the reciprocal value of the density.

The variable type is Output.
The unit is meter cube per kilogram [m^3 / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

spec. volume v"

It is the specific volume for the gaseous phase, which is the volume that is occupied per kilogram. It is at least the reciprocal value of the density.

The variable type is Output.
The unit is meter cube per kilogram [m^3 / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

intrinsic energy u'

It is the intrinsic energy for the liquid phase (solid phase only while sublimation) contained in one kilogram. It is the internal energy which can consist of different energy forms and which is assumed to be constant for a system.

The variable type is Input or Output.
The unit is kilo-Joule per kilogram [kJ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

intrinsic energy u”

It is the intrinsic energy for the gaseous phase contained in one kilogram. It is the internal energy which can consist of different energy forms and which is assumed to be constant for a system.

The variable type is Input or Output.
The unit is kilo-Joule per kilogram [kJ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

delta intrinsic energy

It is the difference between the intrinsic energies per kilogram for the liquid phase (solid phase only while sublimation) and the gaseous phase. It is the difference of the internal energies which can consist of different energy forms and which are assumed to be constant for a system.

The variable type is Input or Output.
The unit is kilo-Joule per kilogram [kJ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

enthalpy h’

It is the enthalpy for the liquid phase (solid phase only while sublimation) per kilogram. The enthalpy is the sum up of the internal energy and the pressure volume work.

The variable type is Input or Output.
The unit is kilo-Joule per kilogram [kJ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

enthalpy h”

It is the enthalpy for the gaseous phase per kilogram. The enthalpy is the sum up of the internal energy and the pressure volume work.

The variable type is Input or Output.
The unit is kilo-Joule per kilogram [kJ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

delta enthalpy

It is the difference of the enthalpies for the liquid phase (solid phase only while sublimation) and the gaseous phase per kilogram. The enthalpy is the sum up of the internal energy and the pressure volume work.

The variable type is Input or Output.
The unit is kilo-Joule per kilogram [kJ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

entropy s'

It is the entropy for the liquid phase (solid phase only while sublimation) per kilogram. The entropy of a system changes, if heat is transferred into or out of the system. The entropy is a measure for the disorder of a system.

The variable type is Input or Output.
The unit is meter cube per kilogram and Kelvin [kJ / (kg K)].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

entropy s"

It is the entropy for the gaseous phase per kilogram. The entropy of a system changes, if heat is transferred into or out of the system. The entropy is a measure for the disorder of a system.

The variable type is Input or Output.
The unit is meter cube per kilogram and Kelvin [kJ / (kg K)].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

delta entropy

It is the difference between the entropy of the liquid phase (solid phase only while sublimation) and the gaseous phase per kilogram. The entropy of a system changes, if heat is transferred into or out of the system. The entropy is a measure for the disorder of a system.

The variable type is Input or Output.
The unit is meter cube per kilogram and Kelvin [kJ / (kg K)].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

12.2.3. Operation (How can it be used? How to proceed?)

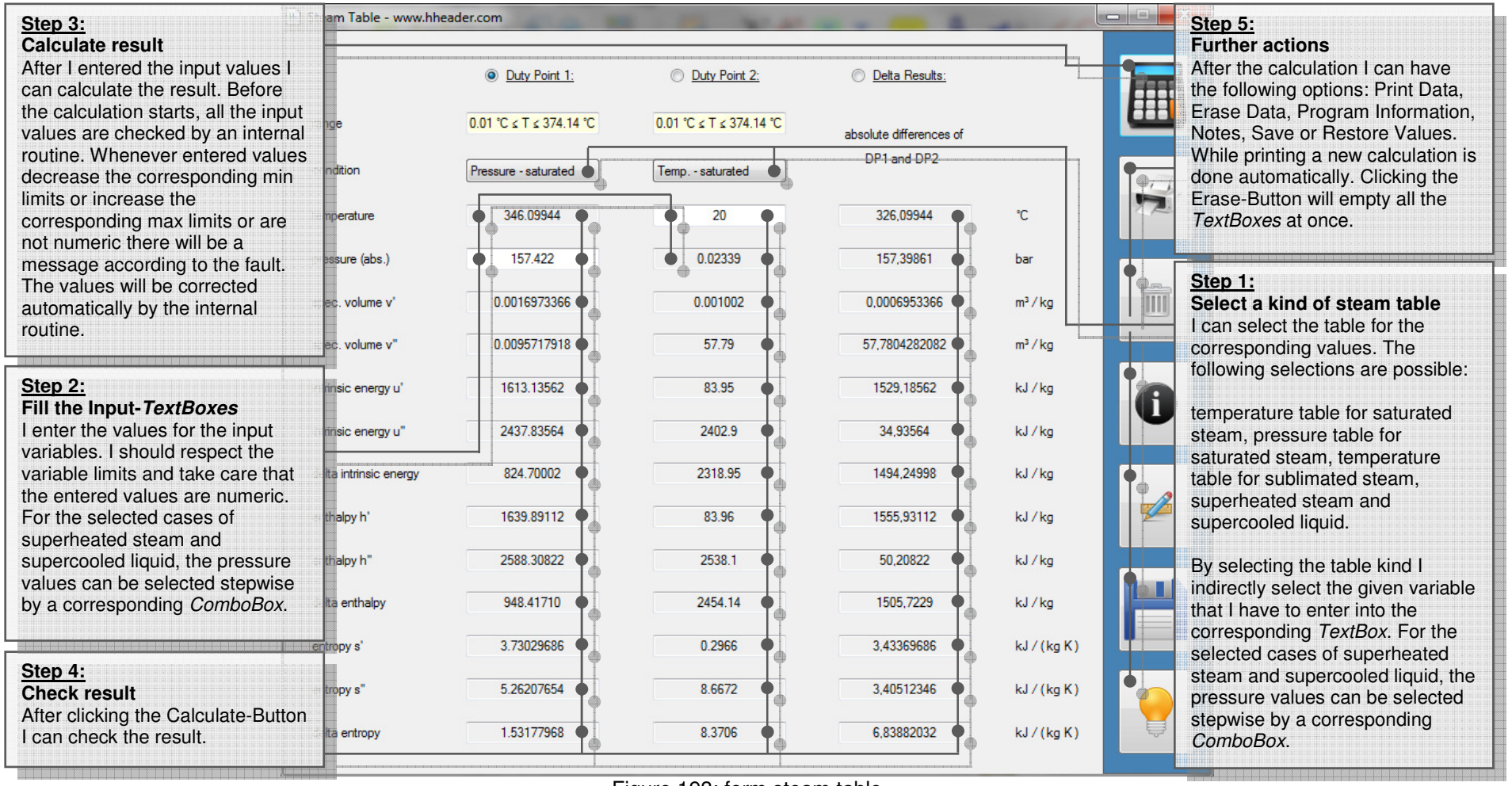


Figure 193: form steam table

12.3. Coefficient Valve

12.3.1. Purpose (What can it be used for? What can it not be used for?)

The program is part of category 7 – mixed. The valve coefficient is a measure for the flow rate that can pass through a valve with respect to the pressure drop under the given circumstances. The valve coefficient that is also known as KV-value is relevant for an adequate choice of a proper valve type. Depending on the fluid there are different equations with different variables to consider. Calculations for liquids, gases and steam are provided. The required given variables with respect to the fluid are as follows:

The differential pressure which is the difference between the pressure at the valve inlet and the pressure at the valve outlet is relevant for all three calculations. For the liquids density and flow rate respectively the resulting mass flow are relevant. For the gases also the temperature has to be taken into consideration. Regarding the steam the saturation temperature, the actual temperature, the specific volume and the mass flow are important.

The coefficient for the valve (KV-value) gives at least the flow rate that will cause a pressure drop of approximately one bar while passing through the valve under the given circumstances. The KV-value and the KVS-value are in coherence with each other. The KVS-value is greater than the KV-value. Depending on the type of valve there are different factors to consider. In case if there are no KVS-values available in the valve documentation, a range for the factors from 0.75 to 0.9 can be assumed as default value. The KV-value divided by the factor results the KVS-value. It is the maximum flow rate that should be forced through the valve.

The KV-value is for metric measures. For non-metric systems the CV-value is sometimes given. The relation between these two values is KV-value = 0.86 x CV-value for the US and KV-value = 1.04 x CV-value for the UK which comes from the different gallon units.

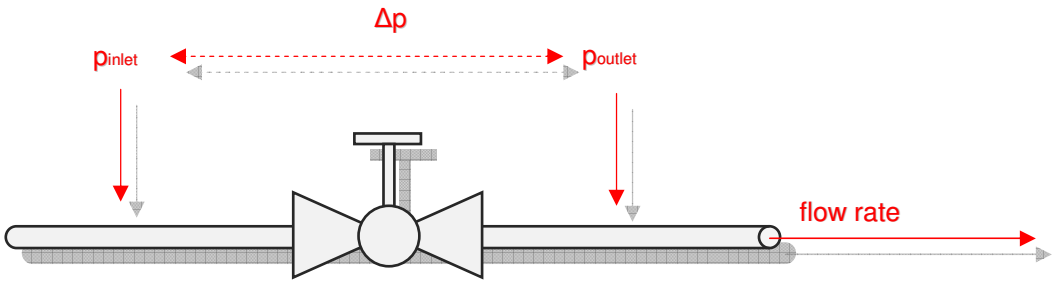


Figure 194: sketch coefficient valve

Terms of pressure

Handling the steam table requires to be familiar with some different terms of pressure. The following descriptions should give an adequate overview regarding the use of the programs.

zero pressure (vacuum)

The zero pressure (vacuum) is the pressure in a physically perfect vacuum (empty space, e.g. outer space). The theoretical value is zero bar. It is the reference value for the absolute pressure value.

zero pressure altitude

The zero pressure altitude is the altitude measured from the earth surface, where the pressure is almost equal the zero pressure (vacuum). This is approximately 100 km above the mean-sea level (Kármán-Line).

atmospheric pressure

The atmospheric pressure is an external pressure, which is affected by many different and various parameters (weather, altitude, etc.). The atmospheric pressure is changing continuously and is never constant.

ambient pressure

The ambient pressure is the external pressure at a defined location. In most cases this is equal to the atmospheric pressure as long as rooms are not pressure-capsulated. The ambient pressure can also be artificially induced e.g. in a pressure chamber.

standard pressure

The standard pressure is a reference point for many physically and technically procedures (1013.25 mbar absolute). It is the value of the assumed atmospheric pressure at the mean sea-level on earth.

differential pressure

The differential pressure is the difference between two pressure levels ($\Delta p = p1 - p2$). Pressure measuring can only take place to a reference pressure level.

gauge pressure

The gauge pressure is the measured differential pressure to the surrounding ambient pressure. It is a relative pressure. Pressure measuring can only take place to a reference pressure level.

absolute pressure

The absolute pressure is the differential pressure to the zero pressure of a physically perfect vacuum.

Relations

+ generally	The absolute pressure value is equal to gauge pressure value plus the atmospheric pressure value.	$p_{abs} = p_{gauge} + p_{atm}$
+ practically	The absolute pressure value is equal to gauge pressure value plus the standard pressure value of 1013.25 mbar (location earth, mean see level).	$p_{abs} = p_{gauge} + p_{sta}$

Pressure gradient: subcritical and overcritical

The pressure at the inlet and the outlet of the valve are relevant parameters for the determination of the KV-Value. There are different formulas to be considered depending on the pressure gradient where two cases are defined.

1.	The subcritical pressure gradient, where the pressure difference between inlet and outlet is less than the half of the inlet pressure, which means that the outlet pressure is greater than the inlet pressure.	$\Delta p < p_{IN} / 2$	$p_{OUT} > p_{IN} / 2$
2.	The subcritical pressure gradient, where the pressure difference between inlet and outlet is less than the half of the inlet pressure, which means that the outlet pressure is greater than the inlet pressure.	$\Delta p < p_{IN} / 2$	$p_{OUT} > p_{IN} / 2$

Hereby Δp is the difference between the inlet and outlet pressure ($\Delta p = p_{IN} - p_{OUT}$). The different cases are considered by the program, automatically.

Calculation methods regarding the valve coefficient for steam

Regarding the calculation of the valve coefficient for steam as fluid there are two different calculation methods (A + B) provided. The calculation method can be selected via a *ComboBox* on the right side in the top of the *TabPage* with the steam calculations. The characteristics of the two different methods are as follows:

A Considers the pressure gradient. The different cases are considered by the program, automatically.

While the pressure gradient is subcritical the method considers the specific steam volume in the curve of the outlet pressure value with respect to the given temperature input value. The saturation temperature that is in coherence with the pressure curve is base for the minimum temperature value. Beside this the differential pressure of inlet and outlet and a decimal factor are used.

While the pressure gradient is overcritical the method considers the specific steam volume in the curve of the half inlet pressure value with respect to the given temperature input value. The saturation temperature that is in coherence with the pressure curve is base for the minimum temperature value. Beside this the inlet pressure value and a decimal factor are used.

B Considers the pressure gradient. The different cases are considered by the program, automatically.

While the pressure gradient is subcritical the method considers the given temperature input value. The saturation temperature that is in coherence with the inlet pressure is base for the minimum temperature value. Beside this the differential pressure of inlet and outlet, the outlet pressure value and a decimal factor are used.

While the pressure gradient is overcritical the method considers the given temperature input value. The saturation temperature that is in coherence with the inlet pressure is base for the minimum temperature value. Beside this the inlet pressure value and a decimal factor are used.

12.3.2. Variables (What are the input and output values? What are their limits?)

pressure inlet (abs.)

It is the absolute pressure value at the inlet of the valve. A usual pressure gauge shows the pressure difference to the atmosphere. That means the actual atmospheric pressure value (1013.25 mbar under standard circumstances) and the gauge pressure value need to be added in order to determine the absolute pressure value. So the absolute pressure is approximately one bar above the gauge value.

The variable type is Input.
The unit is bar [bar].
The minimum limit is 0.01.
The maximum limit is 220.9.
The replacement value is 2.
The number of digits is 10.

pressure outlet (abs.)

It is the absolute pressure value at the outlet of the valve. A usual pressure gauge shows the pressure difference to the atmosphere. That means the actual atmospheric pressure value (1013.25 mbar under standard circumstances) and the gauge pressure value need to be added in order to determine the absolute pressure value. So the absolute pressure is approximately one bar above the gauge value.

The variable type is Input.
The unit is bar [bar].
The minimum limit is 0.01.
The maximum limit is 220.9.
The replacement value is 2.
The number of digits is 10.

pressure difference

It is the pressure difference between the inlet and the outlet of the valve. Obviously the pressure at the inlet is always greater than the pressure at the outlet of the valve.

The variable type is Output.
The unit is bar [bar].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

density

It is the density of the fluid that is passing through the valve. The program provides calculations for liquid, gas and steam. The density is depending on the temperature. In case if a high accuracy is required for the calculations this has to be considered.

The variable type is Input.
The unit is kilogram per meter cube [kg / m^3].
The minimum limit is 0.001.
The maximum limit is 9999.
The replacement value is 1000.
The number of digits is 10.

flow rate

It is the flow rate for the fluid that is passing through the valve. The flow rate by the density results the mass flow that is required for the further calculations.

The variable type is Input.
The unit is meter cube per hour [m³ / h].
The minimum limit is 0.001.
The maximum limit is 9999999999.
The replacement value is 100.
The number of digits is 10.

temperature

It is the actual temperature of the fluid that is passing through the valve.

The variable type is Input.
The unit is degree Celsius [°C].
The minimum limit is 0.
The maximum limit is 1000.
The replacement value is 20.
The number of digits is 10.

sat. temperature

It is the saturation temperature for the water vapor which is corresponding to the considered duty point. The saturation temperature depends on the actual pressure. It is the temperature where the water vapor has its minimum thermal energy without precipitating or where the liquid water has its maximum thermal energy without evaporating.

The variable type is Output.
The unit is degree Celsius [°C].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

spec. volume

It is the specific volume for the phase, which is the volume that is occupied per kilogram. It is at least the reciprocal value of the density.

The variable type is Output.
The unit is meter cube per kilogram [m³ / kg].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

mass flow

It is the mass flow that is passing through the valve. Regarding the calculations for liquids and for gases the mass flow results from the corresponding flow rate multiplied by the corresponding density as an output variable. For the steam calculations it is a given input variable.

The variable type is Input or Output.
The unit is kilogram per hour [kg / h].
The minimum limit is 0.001.
The maximum limit is 9999999999.
The replacement value is 100.
The number of digits is 10.

factor valve type

The KVS-value can be determined by the coefficient for the valve (KV-value) and a factor for the valve type. The KV-value gives the flow rate that will cause a pressure drop of one bar while passing through the valve under the given circumstances. The KV-value and the KVS-value are in coherence to each other. The factor is at least equal the KV-value over the KVS-value.

The variable type is Input.
The unit is meter cube per hour [-].
The minimum limit is 0.1.
The maximum limit is 1.
The replacement value is 0.75.
The number of digits is 10.

KV-value

It is the coefficient for the valve (KV-value) that gives the flow rate that will cause a pressure drop of one bar while passing through the valve under the given circumstances. The KV-value and the KVS-value are in coherence to each other. The KVS-value is greater than the KV-value. Depending on the type of valve there are different factors to consider.

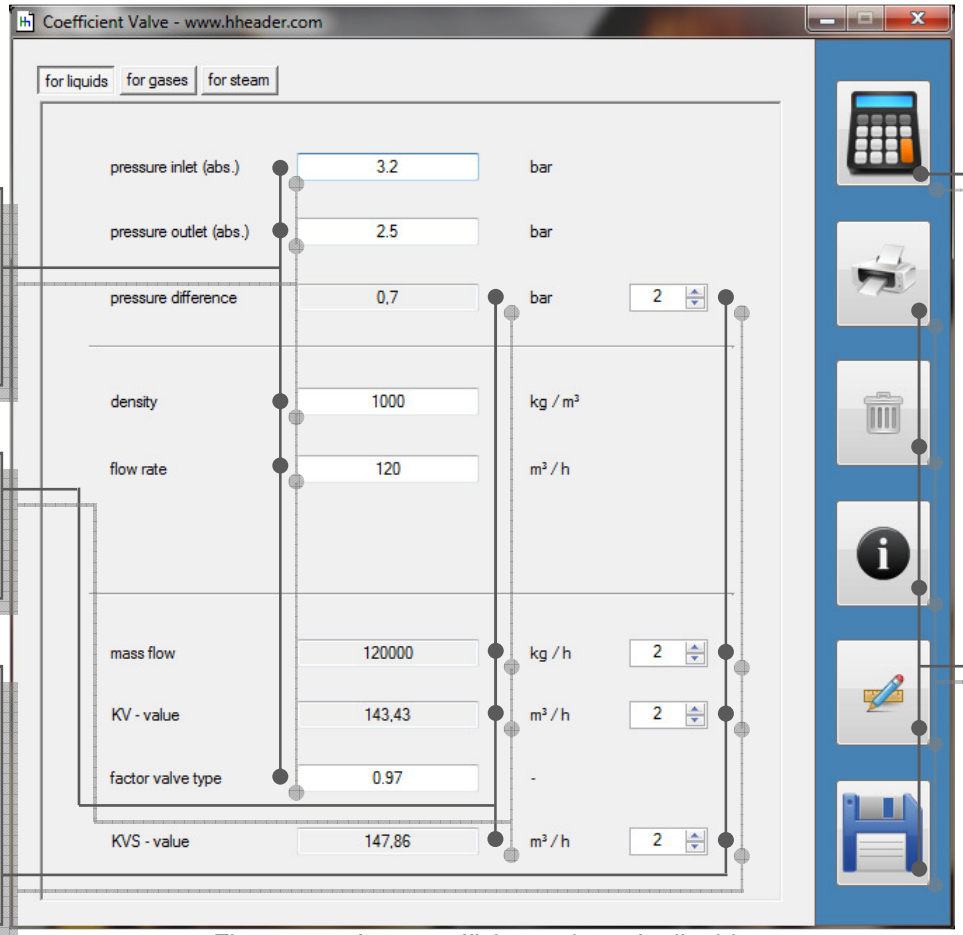
The variable type is Output.
The unit is meter cube per hour [m^3 / h].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

KVS-value

It results from the coefficient for the valve (KV-value) and a factor for the valve type. The KV-value gives the flow rate that will cause a pressure drop of one bar while passing through the valve under the given circumstances. The KV-value and the KVS-value are in coherence to each other. The KVS-value is greater than the KV-value. Depending on the type of valve there are different factors to consider.

The variable type is Output.
The unit is meter cube per hour [m^3 / h].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

12.3.3. Operation (How can it be used? How to proceed?)



Step 1:
Fill the Input-*TextBoxes*
I enter the values for the input variables. I should respect the variable limits and take care that the entered values are numeric.

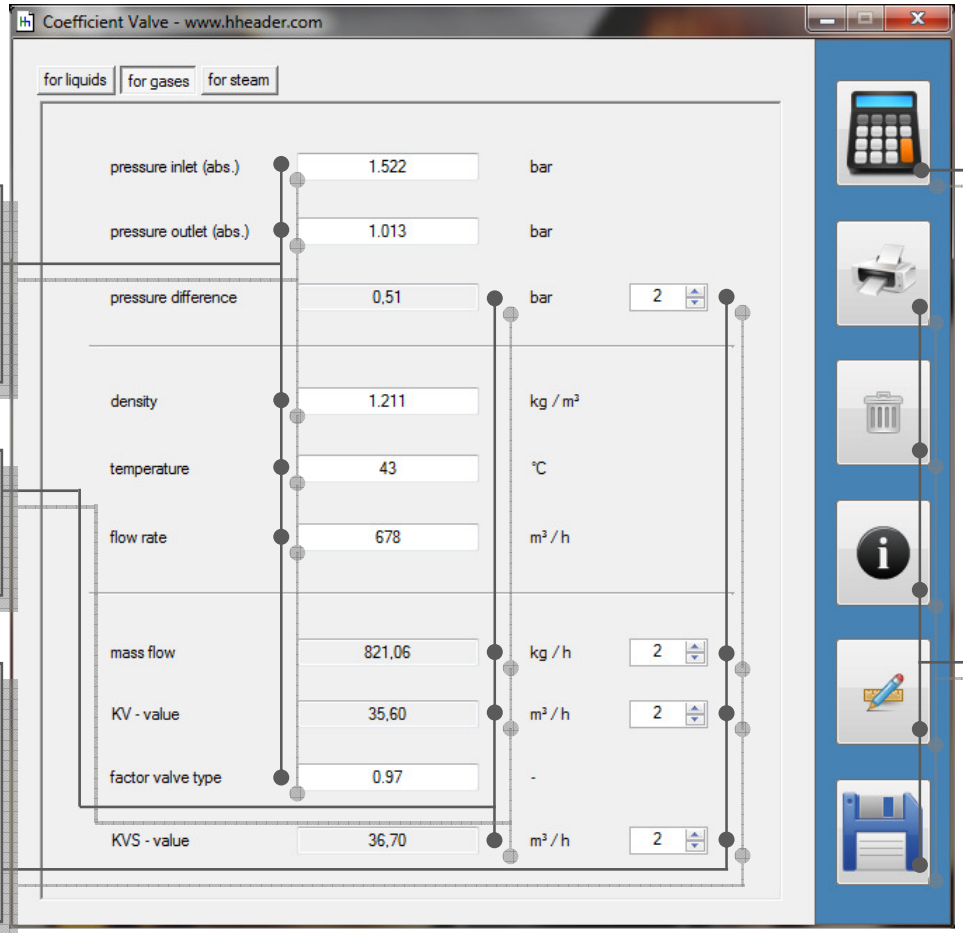
Step 2:
Enter the number of decimal places
I enter the number of decimal places for the variables. It is valid only if the corresponding variable is selected as output. The input variables can get more or less decimal numbers according to the number of digits.

Step 3:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 4:
Check result
After clicking the Calculate-Button I can check the result.

Step 5:
Further actions
After the calculation I can have the following options: Print Data, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

Figure 195: form coefficient valve – for liquids



Step 1:
Fill the Input-*TextBoxes*
I enter the values for the input variables. I should respect the variable limits and take care that the entered values are numeric.

Step 2:
Enter the number of decimal places
I enter the number of decimal places for the variables. It is valid only if the corresponding variable is selected as output. The input variables can get more or less decimal numbers according to the number of digits.

Step 3:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 4:
Check result
After clicking the Calculate-Button I can check the result.

Step 5:
Further actions
After the calculation I can have the following options: Print Data, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

Figure 196: form coefficient valve – for gases

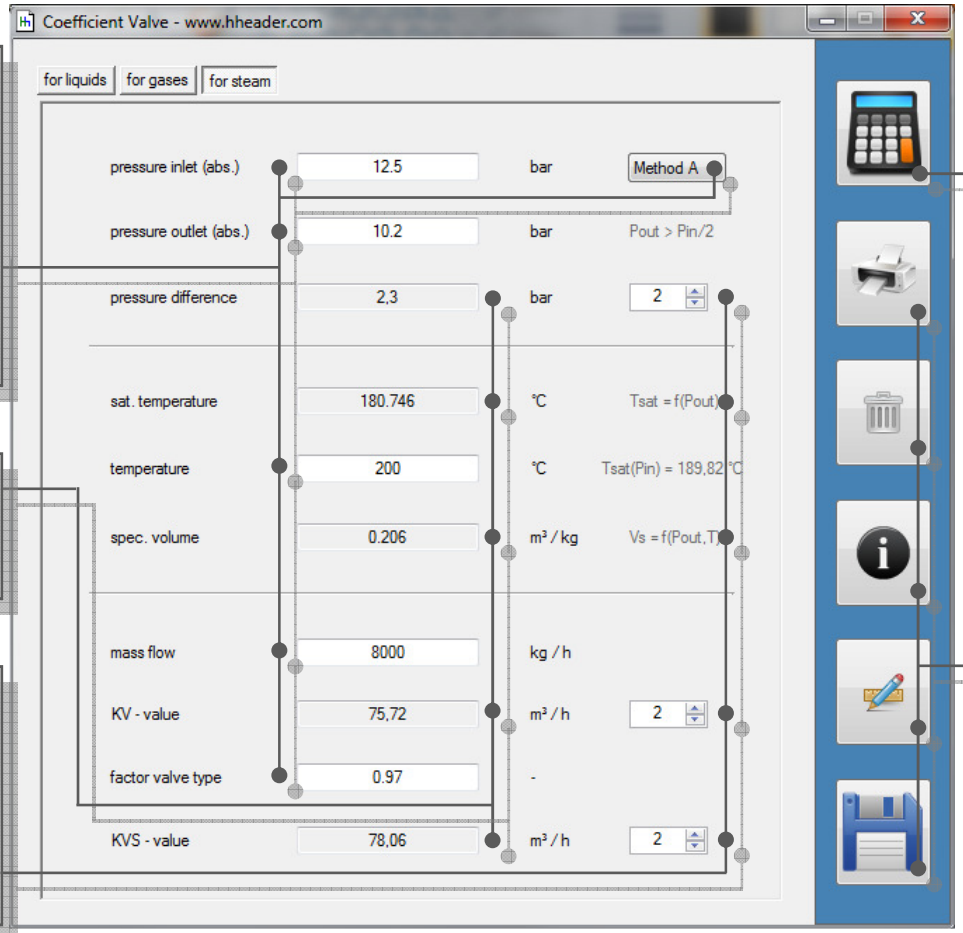
Step 1:
Fill the Input-*TextBoxes*
I enter the values for the input variables. I should respect the variable limits and take care that the entered values are numeric.

Select the calculation method

I select the calculation method (A or B) on the last TabPage if required.

Step 4:
Check result
After clicking the Calculate-Button I can check the result.

Step 2:
Enter the number of decimal places
I enter the number of decimal places for the variables. It is valid only if the corresponding variable is selected as output. The input variables can get more or less decimal numbers according to the number of digits.



Step 3:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 5:
Further actions
After the calculation I can have the following options: Print Data, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

Figure 197: form coefficient valve – for steam

12.4. Open Area Valve

12.4.1. Purpose (What can it be used for? What can it not be used for?)

The program is part of category 7 - mixed. Control valves react on different process circumstances. In order to adjust the target value they open or close step by step according to the adjusted controller parameters. In case of continuous and stabile process conditions the valve operates in a predictable range as percentage value of its opening grade. This depends on the valve type. The program provides calculations for three different valve types. These are butterfly valve, ball valve and gate valve for a circular cross section pipe. The effective control point is the grade of opening as a percentage value of the specific measures for the valve types. For the butterfly valve and the ball valve it is the opening angle (0° to 90° is equal 0% to 100%) and for the gate valve it is the opening height (0 mm to 1 x D in mm is equal 0% to 100%) that is relevant. The projected open area can be an important measure for evaluation purposes. It results out of the pipe diameter and the effective control point for the valve under consideration of the used valve type with its specific opening measure. The valve type can be selected via the corresponding item in the *ComboBox* on the left side in the lower part of the form. The factor for the areas is here defined as the percentage relation between the open area and the total area, which is the cross section of the circular pipe according to its diameter. Therefore the open area is the enumerator and the total area is the denominator. So a value for the factor of 100% means a completely opened valve.

One of the two variables, either the effective control point or the factor for the areas, can be selected as output variable. The residual one and the diameter are input variables. The values for the open area and the total areas are calculated. Based on the relation of the open area and the total area conclusions for the friction coefficient zeta are possible, which are exactly enough for a practical rough calculation. The calculations are deviated from the considerations of Jung.

Curves for the three valve types are displayed in a diagram. The curves have a qualitative character. The y-axis shows the factor for the areas, which is the percentage relation between the open area and the total area. The x-axis shows the opening grade for the valve as percentage value. For the butterfly valve and the ball valve it is the opening angle (0° to 90° is equal 0% to 100%) and for the gate valve it is the opening height (0 mm to 1 x D in mm is equal 0% to 100%) that is relevant. Also a curve for the friction coefficient with respect to the opening grade can be displayed. This curve has also a qualitative character. It can be shown by selecting the corresponding item in the *ComboBox* on the right side in the lower part of the form.

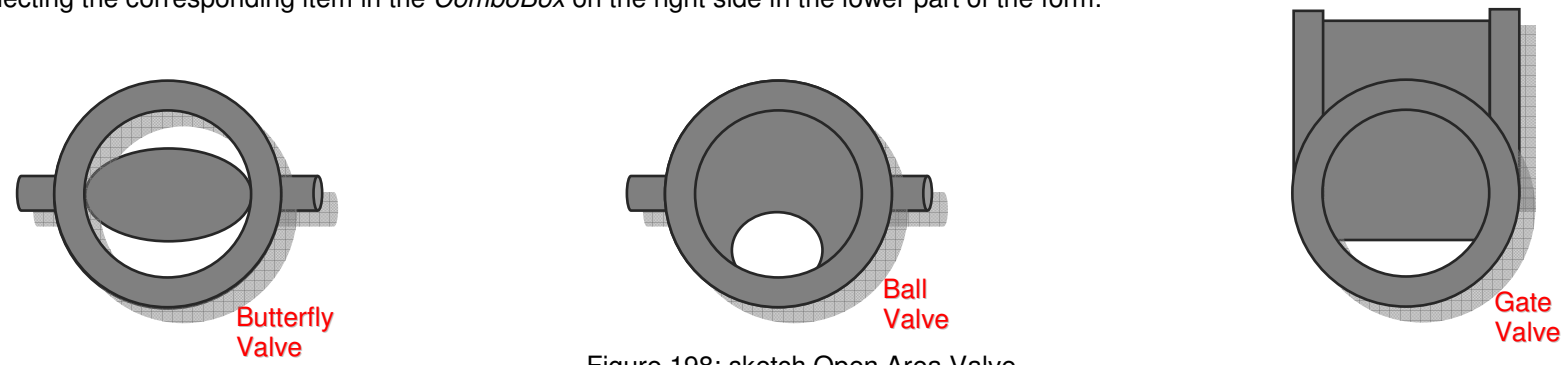


Figure 198: sketch Open Area Valve

12.4.2. Variables (What are the input and output values? What are their limits?)

eff. control point

It is the effective control point for the corresponding valve position. For the butterfly valve and the ball valve it is equal to the opening angle, where 0° (0%) means the valve is completely closed and 90° (100%) means the valve is fully open. For the gate valve the control point is equal to the opening height in relation to the total pipe diameter. All positions in between are throttled positions.

The variable type is Input or Output.
The unit is percent [%].
The minimum limit is 0.1.
The maximum limit is 100.
The replacement value is 50.
The number of digits is 10.

diameter

It is the diameter of the valve respectively the pipe where the valve is installed. The pipe is assumed to have a circular cross section. The valve is a butterfly valve, a ball valve or a gate valve.

The variable type is Input.
The unit is millimeter [mm].
The minimum limit is 0.1.
The maximum limit is 99999.
The replacement value is 200.
The number of digits is 10.

factor for areas

It is the open area depending on the valve position respectively the effective control point in relation to the total area by hundred. It gives back how many percentage of the total area are not covered by the projected area of the valve flap (butterfly valve), valve ball (ball valve) or the valve plate (gate valve). The factor is a base value for the determination of the resistance coefficient zeta.

The variable type is Input or Output.
The unit is percent [%].
The minimum limit is 0.001.
The maximum limit is 100.
The replacement value is 50.
The number of digits is 10.

zeta

It is the resistance coefficient for the corresponding valve type at the given effective control point. For the program there is a selection of different valve types provided. These are: butterfly valve, ball valve and gate valve.

The variable type is Output.
The variable has no unit [-].
There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

Attention: the calculated zeta values are base values with respect to the open area percentage value. Additionally the zeta value depends on many different parameters (e.g. pipe diameter respectively the pipe measures, roughness, velocity etc.). This can be considered manually by an extra factor. The user has to take care for this himself or herself, accordingly!

Further it has to be taken into consideration that it is not too rare that many valves cannot release any flow before the opening measure is in a range from e.g. 10-20%, which is mainly based on the gasket design.

total area

It is total area of the valve or the pipe, where at least also the projected area of the valve flap, ball or plate is disregarded in the fully open position.

The variable type is Output.
For this variable a selection of different units is provided:

- millimeter square [mm²],
- centimeter square [cm²],
- meter square [m²].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

open area

It is the open area for the valve or pipe, where the projected area of the valve flap, ball or plate which is in coherence with the opening measure, is subtracted from the total area.

The variable type is Output.
For this variable a selection of different units is provided:

- millimeter square [mm²],
- centimeter square [cm²],
- meter square [m²].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

12.4.3. Operation (How can it be used? How to proceed?)

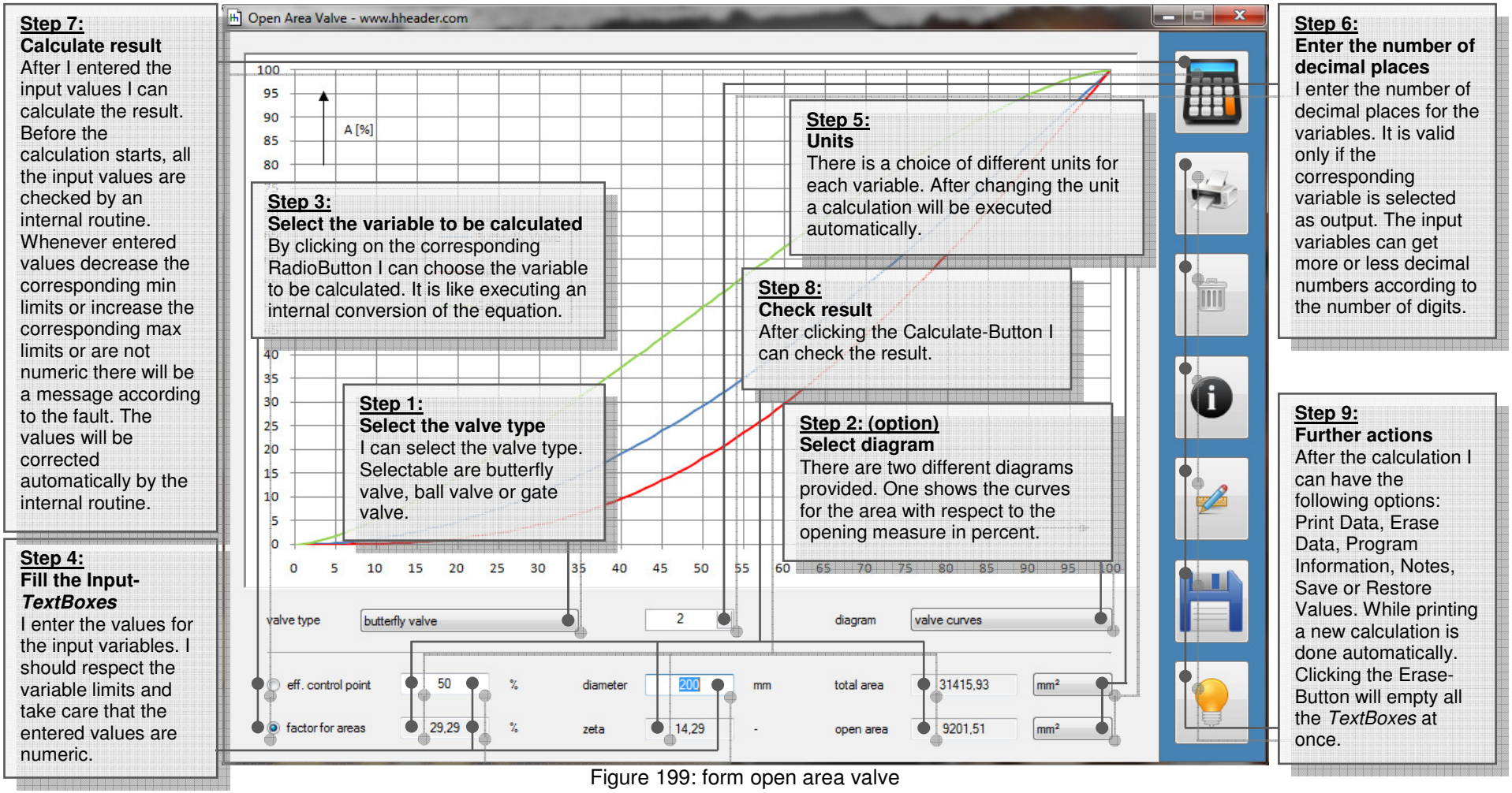


Figure 199: form open area valve

12.5. Reduction Rate

12.5.1. Purpose (What can it be used for? What can it not be used for?)

The program is part of category 7 – mixed. Reduction processes can be relevant for the treatment in different use cases. They can have a biological, a physical or a chemical inducement. Even a combination of two or three of them is possible. Although the reduction is in almost every case not constant, a linear approximation can be used in many cases for a long term evaluation, if realistic average values for the degradation efficiency are considered.

To cover most of the possible cases, the following situation is simulated by the program. A certain volume of a solution with a certain density and a certain concentration of matter appears x times, where x can be a natural number from 0 to 99. The total mass of matter inside the solution that results according to the given values is distributed or diluted in a total volume (e.g. a reactor) respectively otherwise into contact with a total volume (contact volume). Further it is supposed that the mass of matter is reduced linear by time down to a final concentration which is below the start concentration or even equal zero, which means that the amount of matter has been consumed totally.

In case if the mass of matter is known from the beginning and the matter itself is not dissolved or diluted in a solution, there are different possibilities to set the corresponding mass easily. One way, which is probably the easiest one, is shown by the following procedures:

Setting the mass product in milligram:

- select the unit “mm³” (millimeter cube) for the “volume solution”,
- select the unit “%” (percent) for the “conc. solution”,
- select the unit “kg / l” (kilogram per liter) for the “density solution”,
- select the unit “mg” (milligram) for the “mass product”,
- adjust a value of “1” for the amount,
- set the concentration to “100%”,
- set the density to “1 kg / l”,
- enter the value for the mass in mg as the volume solution.

Setting the mass product in gram:

- select the unit “cm³” (centimeter cube) for the “volume solution”,
- select the unit “%” (percent) for the “conc. solution”,
- select the unit “kg / l” (kilogram per liter) for the “density solution”,
- select the unit “g” (gram) for the “mass product”,
- adjust a value of “1” for the amount,
- set the concentration to “100%”,
- set the density to “1 kg / l”,
- enter the value for the mass in g as the volume solution.

Setting the mass product in kilogram:

- select the unit “l” (liters) for the “volume solution”,
- select the unit “%” (percent) for the “conc. solution”,
- select the unit “kg / l” (kilogram per liter) for the “density solution”,
- select the unit “kg” (kilogram) for the “mass product”,
- adjust a value of “1” for the amount,
- set the concentration to “100%”,
- set the density to “1 kg / l”,
- enter the value for the mass in kg as the volume solution.

Generally the calculation is divided up into three parts:

The first part is the calculation of the total mass of matter that is assumed to be reduced. This is done by multiplication of the amount by the volume by the concentration by the density of the solution under consideration of the corresponding units.

The second part is the calculation of the total concentration of matter in relation to the total volume (contact volume) where the mass product is finally distributed or diluted respectively otherwise into contact with the total volume. This is done by putting the mass product into relation with the total volume multiplied by a reduction factor under consideration of the corresponding units.

The third part is the calculation for the reduction process (degradation) itself. Therefore the reduction time is determined from the difference of the total and the final concentration in relation to the reduction rate (degradation efficiency) under consideration of the corresponding units.

The program provides eight rows where eight separate calculations can be carried out at once. Therefore the *CheckBoxes* left side from each row need to be checked accordingly in order to activate the row for the calculation. Only activated rows will be included in the calculation. Be aware that the adjusted units are relevant for all activated rows. For each row a designation can be defined as string variable.

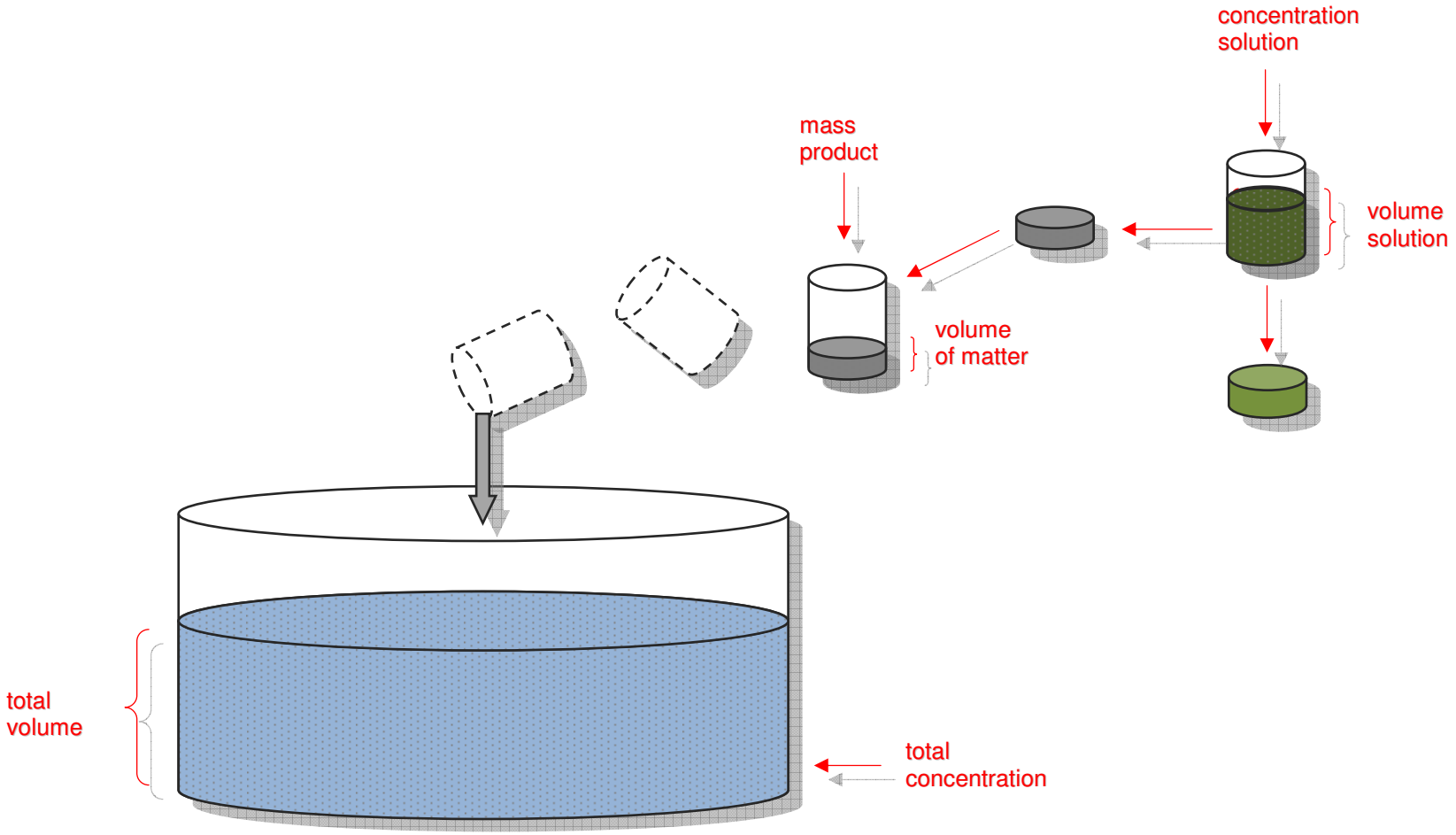


Figure 200: sketch reduction rate

12.5.2. Variables (What are the input and output values? What are their limits?)

amount

It is the amount of the single solution units which are focus for the calculations. Each solution can be divided up into defined volume packages. Thereby it can later easily be multiplied by increasing or divided by decreasing the amount.

The variable type is Input.
The variable has no unit [-].
The minimum limit is 0.
The maximum limit is 99.
The variable has no replacement value.
The number of digits is 2.

volume solution

It is the volume of the single solution unit that is focus for the calculations. Each solution can be divided up into defined volume packages. Thereby it can later easily be multiplied by increasing or divided by decreasing the amount.

The variable type is Input.
For this variable a selection of different units is provided:

- millimeter cube [mm^3],
- centimeter cube [cm^3],
- centiliter [cl],
- liter [l],
- meter cube [m^3].

The minimum limit is 0.001.
The maximum limit is 99999999.
The replacement value is 100.
The number of digits is 5.

conc. solution

It is the concentration of the single solution unit which gives at least the content of the corresponding matter in relation to the total amount of the solution.

The variable type is Input.
For this variable a selection of different units is provided:

- parts per quadrillion [ppq],
- parts per trillion [ppt],
- parts per billion [ppb],
- parts per million [ppm],
- per mille [per mille],
- percent [%].

The minimum limit is 0.0001.
The maximum limit is 9999999999.
The replacement value is 100.
The number of digits is 5.

density solution

It is the density of the single solution unit that is focus for the calculations. Each solution can be divided up into defined volume packages. Thereby it can later easily be multiplied by increasing or divided by decreasing the amount.

The variable type is Input.
For this variable a selection of different units is provided:

- kilogram per liter [kg / l],
- kilogram per meter cube [kg / m^3].

The minimum limit is 0.001.
The maximum limit is 29999.
The replacement value is 1.
The number of digits is 5.

mass product

It is the mass of matter that is content of the corresponding amount of solution units. It results as product from the multiplication of the amount, the concentration and the density. The mass of matter is getting in contact with the total volume (contact volume).

The variable type is Output.
For this variable a selection of different units is provided:

- picogram [pg]
- nanogram [ng],
- microgram [µg],
- milligram [mg],
- gram [g],
- kilogram [kg],
- tons [tons].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

total volume

It is the total volume (contact volume) where the mass product is finally distributed or diluted respectively otherwise into contact. In case if this cannot take place totally or immediately, it can be considered by the factor for reduction.

The variable type is Input.
For this variable a selection of different units is provided:

- millimeter cube [mm³],
- centimeter cube [cm³],
- liter [l],
- meter cube [m³].

The minimum limit is 0.001.
The maximum limit is 99999999.
The replacement value is 100.
The number of digits is 5.

factor reduction

The mass product is assumed to be filled in or respectively to get in contact with the total volume. In case if this cannot take place totally or immediately, it can be considered by the factor for reduction. This means that for any reason at least only a percentage value of the mass of matter can be involved in the process. The factor needs to be set to 100%, if the total mass can participate.

The variable type is Input.
The unit is percent [%].
The minimum limit is 0.1.
The maximum limit is 90.
The replacement value is 45.
The number of digits is 5.

total conc.

It is the total concentration of matter that is involved in the process in relation to the total volume (contact volume) under consideration of the factor for reduction.

The variable type is Output.
For this variable a selection of different units is provided:

- microgram per liter [µg / l],
- milligram per liter [mg / l],
- gram per liter [g / l],
- gram per meter cube [g / m^3],
- kilogram per meter cube [kg / m^3].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

reduction rate

It is reduction rate (degradation efficiency) for the matter that is content of the total volume or in contact with the total volume. It is assumed that the matter is reduced linearly dependent by biological, chemical or physical processes. The reduction factor gives the mass of matter that is reduced per volume and per time unit.

The variable type is Input.
For this variable a selection of different units is provided:

- microgram per liter per second [µg / (l s)],
- microgram per liter per minute [µg / (l min)],
- microgram per liter per hour [µg / (l h)],
- milligram per liter per second [mg / (l s)],
- milligram per liter per minute [mg / (l min)],
- milligram per liter per hour [mg / (l h)],
- gram per liter per minute [g / (l min)],
- gram per liter per hour [g / (l h)],
- gram per liter per day [g / (l d)],
- gram per meter cube per minute [g / (m^3 min)],
- gram per meter cube per hour [g / (m^3 h)],
- gram per meter cube per day [g / (m^3 d)].
- kilogram per meter cube per minute [kg / (m^3 min)],
- kilogram per meter cube per hour [kg / (m^3 h)],
- kilogram per meter cube per day [kg / (m^3 d)].

The minimum limit is 0.001.
The maximum limit is 99999999.
The replacement value is 100.
The number of digits is 5.

Of course some of the units result the same factors (e.g. kg / m^3 and g / l), but never the less the unit selections are given like this in order to avoid the necessity of a manual unit conversion as far as possible.

spec. final conc.

It is the specified final concentration of matter that is content of the total volume or finally in contact with the total volume. In case if there is a limit above zero that is tolerable, this can be entered as the final concentration in order to get the residual time that it takes to reduce the mass of matter down to the limit. Obviously it makes no sense to set the final concentration greater that the total concentration.

The variable type is Input.
For this variable a selection of different units is provided:

- microgram per liter [µg / l],
- milligram per liter [mg / l],
- gram per liter [g / l],
- gram per meter cube [g / m³],
- kilogram per meter cube [kg / m³].

The minimum limit is 0.
The maximum limit is 1000.
The replacement value is 100.
The number of digits is 5.

reduction time

It is reduction time that results from the total concentration, the reduction rate (degradation efficiency) and the specified final concentration. The reduction time is the time that it takes the process to reduce the mass of matter as content of the total volume down to the specified limit respectively to zero.

The variable type is Output.
For this variable a selection of different units is provided:

- millisecond [ms],
- second [s],
- min [min],
- hour [h],
- day [d],
- month [month],
- year [year].

There is no defined minimum limit for output variables.
There is no defined maximum limit for output variables.
There is no defined replacement value for output variables.
There is no defined number of digits for output variables.

12.5.3. Operation (How can it be used? How to proceed?)

Step 1:
Select the rows to be calculated
I select the rows that should be included in the calculation and the sum-up. By the *CheckBox* in the top, all rows can be selected.

Step 4:
Units
There is a choice of different units for each variable.

Step 5:
Decimal places
I enter the number of decimal places for the variables. The input variables can get more or less decimal numbers according to the number of digits.

Step 6:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 3:
Enter amount
I can enter the amount.

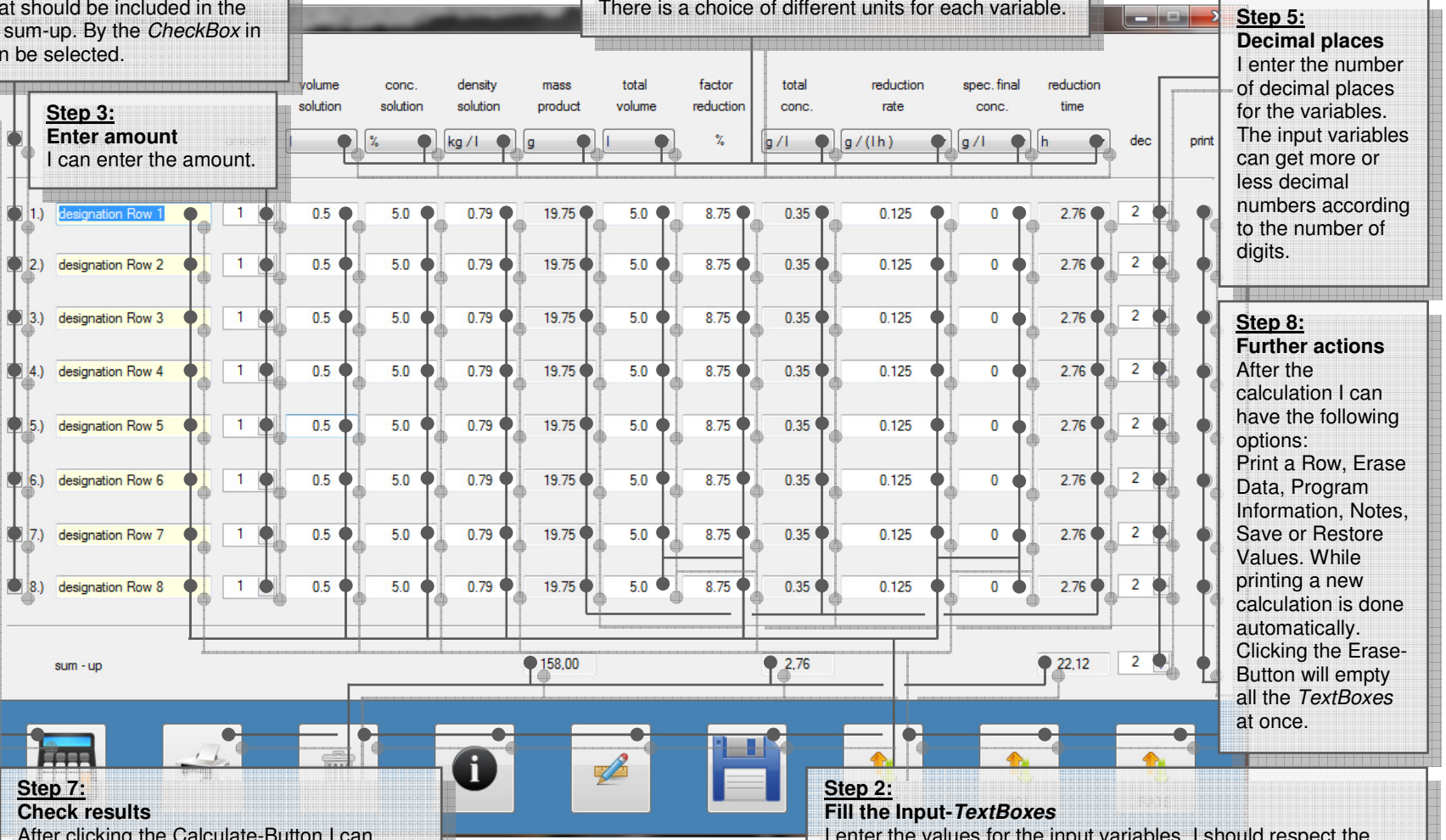


Figure 201: form reduction rate

Step 8:
Further actions
After the calculation I can have the following options:
Print a Row, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

Step 7:
Check results
After clicking the Calculate-Button I can check the results.

Step 2:
Fill the Input-*TextBoxes*
I enter the values for the input variables. I should respect the variable limits and take care that the entered values are numeric.

12.6. Geometry

12.6.1. Purpose (What can it be used for? What can it not be used for?)

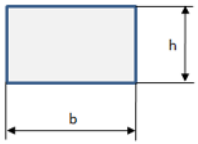
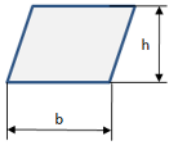
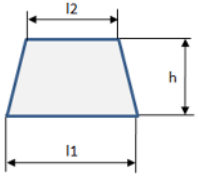
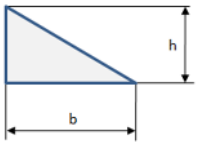
The program is part of category 7 – mixed. From time to time it is required to calculate the area or the volume of different geometric shapes. The program provides different calculations regarding these subjects. For the selection there is a *ComboBox* with two items provided: one for the area calculations and one for the volume calculations. Depending on the selection the different shapes that can be calculated are displayed in the *ListBox* below the *ComboBox*. The following shapes are provided for the area and volume calculations.

area calculations:

- rectangle,
- rhomboid,
- trapeze,
- triangle,
- regular polygon,
- circle,
- circle part,
- circular section,
- circular ring,
- circular ring section,
- ellipse.

volume calculations:

- prism square,
- cylinder,
- hollow cylinder,
- pyramid,
- cone,
- truncated pyramid,
- frustum,
- ball,
- spherical section,
- spherical layer,
- spherical sector.

rectangle		b = ? h = ?
rhomboid		b = ? h = ?
trapeze		l1 = ? l2 = ? h = ?
triangle		b = ? h = ?

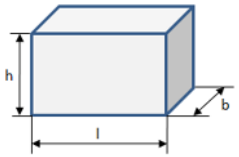
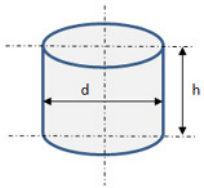
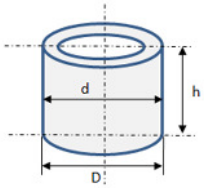
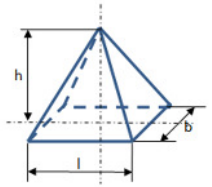
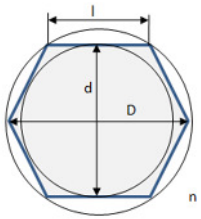
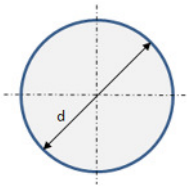
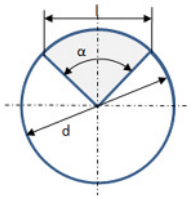
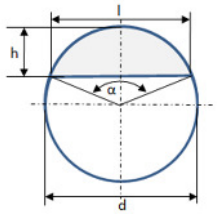
prism square		l = ? b = ? h = ?
cylinder		d = ? h = ?
hollow cylinder		D = ? d = ? h = ? *d ≤ D – 0.5 mm* *A ≤ (D² - 0.1² mm²) π / 4*
pyramid		l = ? b = ? h = ?

Figure 202: sketches geometry block 1 (left areas, right volumes)

regular polygon		D = ? n = ? *5 ≤ n ≤ 360*
circle		d = ?
circle part		d = ? alpha (°) = ? *0.1° ≤ α ≤ 360°* *A ≤ d² π / 4*
circular section		d = ? alpha (°) = ? *0.1° ≤ α ≤ 180°* *A ≤ d² π / 8*

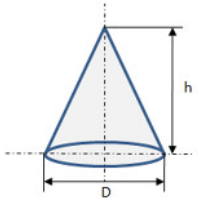
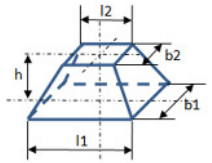
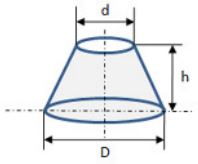
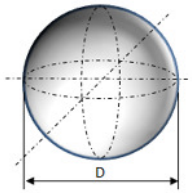
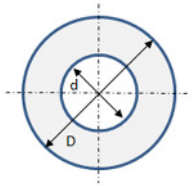
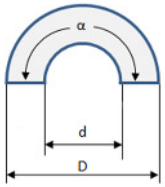
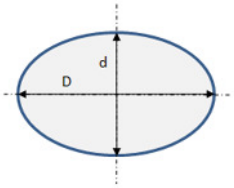
cone		D = ? h = ?
truncated pyramid		l1 = ? b1 = ? l2 = ? b2 = ? h = ? *l2 ≤ l1 – 0.5 mm* *b2 ≤ b1 – 0.5 mm* *V > l1 b1 h / 3*
frustum		D = ? d = ? h = ? *d ≤ D – 0.5 mm* *A ≤ (D² - 0.1² mm²) π / 4*
ball		D = ?

Figure 203: sketches geometry block 2 (left areas, right volumes)

circular ring		D = ? d = ? *d ≤ D – 0.5 mm* *A ≤ (D² - 0.1² mm²) π / 4*
circular ring section		D = ? d = ? alpha (°) = ? *0.1° ≤ α ≤ 360°* *d ≤ D – 0.5 mm* *A ≤ (D² - 0.1² mm²) α π / 4 / 360 respectively* *A ≤ (D^2 - d^2) π / 4*
ellipse		D = ? d = ? *d ≤ D – 0.5 mm* *A > d² π / 4*

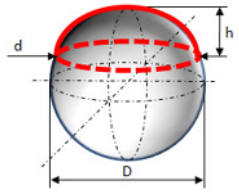
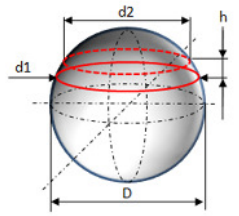
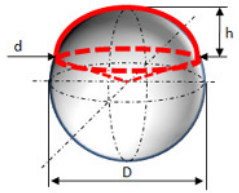
spherical section		D = ? h = ? *h ≤ D* *V ≤ D³ π / 6*
spherical layer		d1 = ? d2 = ? h = ? *h ≤ D*
spherical sector		D = ? h = ? *h ≤ D* *V ≤ D³ π / 6*

Figure 204: sketches geometry block 3 (left areas, right volumes)

For each selection there are different measures defining the shape. For each selected shape it is possible to select one variable as output variable, the residual measures are input variables. The generally used measures are listed in the table below:

- d: inner diameter [mm, cm, m],
- D: outer diameter [mm, cm, m],
- b: breadth, width [mm, cm, m],
- l: length [mm, cm, m],
- h: height [mm, cm, m],
- alpha: angle [°],
- n: amount [-].

The different shapes for the area and volume calculations with the corresponding required measures are displayed in the following table:

area calculations:

- rectangle (b, h),
- rhomboid (b, h),
- trapeze (l1, l2, h),
- triangle (b, h),
- regular polygon (d, l, n),
- circle (d),
- circle part (d, alpha),
- circular section (d, alpha),
- circular ring(D, d),
- circular ring section (D, d, alpha),
- ellipse (D, d).

volume calculations:

- prism square (l, b, h),
- cylinder (d, h),
- hollow cylinder (D, d, h),
- pyramid (l, b, h),
- cone (D, h),
- truncated pyramid (l1, b1, l2, b2, h),
- frustum (D, d, h),
- ball (D),
- spherical section (D, h),
- spherical layer (d1, d2, h),
- spherical sector (D, h).

12.6.2. Variables (What are the input and output values? What are their limits?)

measures (d, D, b, l, h)

Each figure has characteristical measures which define it exactly. The program provides the measures d, D, b, l, h.

The variable type is Input or Output.
For these variables a selection of different units is provided:

- millimeter [mm],
- centimeter [cm],
- meter [m].

The minimum limit is 0.1.
The maximum limit is 999999.
The replacement value is 10.
The number of digits is 10.

angle (alpha)

It is the angle for the corresponding shapes. The angle for a complete circle is 360°. The minimum angle that can be entered is 0.1°. The maximum value is various (180° respectively 360°).

The variable type is Input or Output.
The unit is angular degree [°].
The minimum limit is 0.1.
The maximum limit is 360.
The replacement value is 10.
The number of digits is 10.

amount (n)

It is the amount of corners for the regular polygon.

The variable type is Input or Output.
This variable has no unit [-].
The minimum limit is 5.
The maximum limit is 360.
The variable has no replacement.
The number of digits is 3.

area (A)

It is the corresponding area for the selected shape.

The variable type is Input or Output.
For this variable a selection of different units is provided:

- millimeter square [mm²],
- centimeter square [cm²],
- meter square [m²].

The minimum limit is 0.1.
The maximum limit is 999999.
The replacement value is 10.
The number of digits is 10.

volume (V)

It is the corresponding area for the selected shape.

The variable type is Input or Output.
For this variable a selection of different units is provided:

- millimeter cube [mm³],
- centimeter cube [cm³],
- meter cube [m³].

The minimum limit is 0.1.
The maximum limit is 999999.
The replacement value is 10.
The number of digits is 10.

Implausible values:
Between some values there are different relations to be considered in order to get plausible results. These diverse rules are shown above in the tables with the sketches. The rules will be checked by an internal routine whenever a calculation is initiated. In case if one of these rules is broken, plausible values will be set automatically and a message is shown accordingly. The message text is: "*Entered values are not plausible for the selected system - plausible values are set automatically.*"

12.6.3. Operation (How can it be used? How to proceed?)

Step 1:
Select the figure
After I decided between area and volume, I can select the figure as basis for the calculations.

Step 5:
Decimal places
I enter the number of decimal places for the variables. The input variables can get more or less decimal numbers according to the number of digits.

Step 2:
Select the variable to be calculated
By clicking on the corresponding *RadioButton* I can choose the variable to be calculated. It is like executing an internal conversion of the equation.

Step 3:
Fill the Input-*TextBoxes*
I enter the values for the input variables. I should respect the variable limits and take care that the entered values are numeric.

Step 7:
Check result
After clicking the Calculate-Button I can check the result.

Step 4:
Units
There is a choice of different units for each variable.

Step 6:
Calculate result
After I entered the input values I can calculate the result. Before the calculation starts, all the input values are checked by an internal routine. Whenever entered values decrease the corresponding min limits or increase the corresponding max limits or are not numeric there will be a message according to the fault. The values will be corrected automatically by the internal routine.

Step 8:
Further actions
After the calculation I can have the following options:
Print a Row, Erase Data, Program Information, Notes, Save or Restore Values. While printing a new calculation is done automatically. Clicking the Erase-Button will empty all the *TextBoxes* at once.

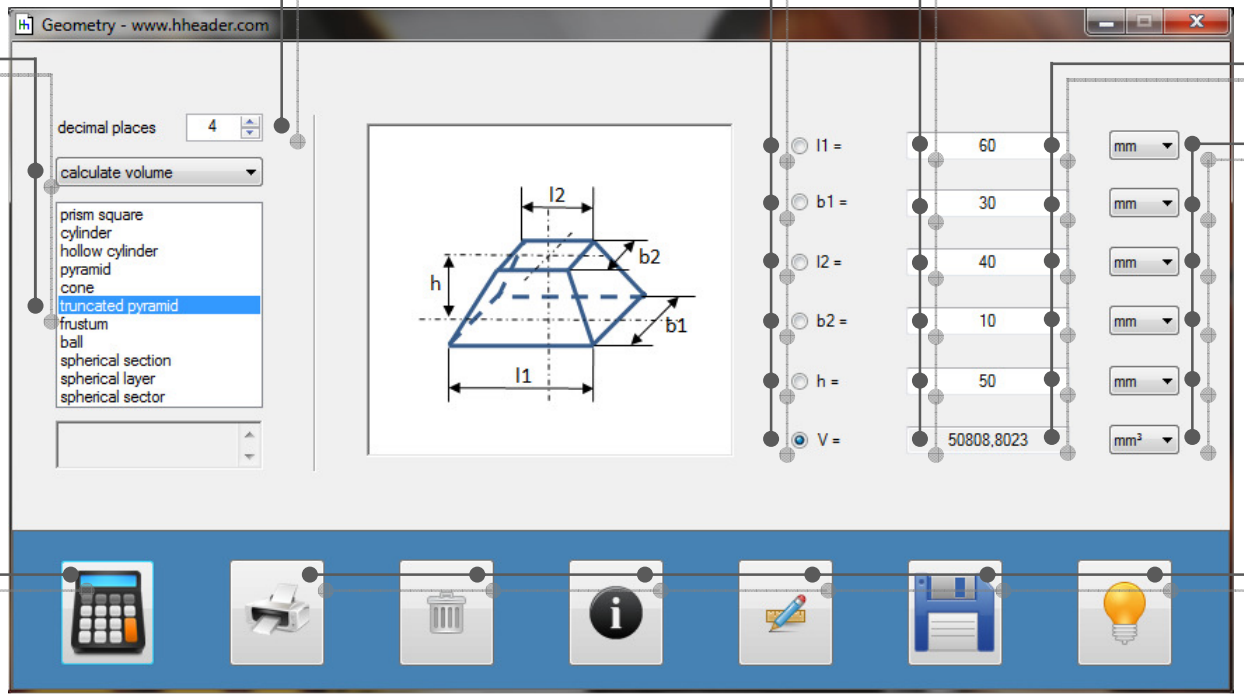


Figure 205: form geometry