



Ingenieurbuero Samoticha
für Verfahrenstechnik

HS-FIRE

Combustion calculation

Version 3.2

User guide

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2 General information

The program makes a comfortable burn calculation possible. Starting from the version 1.2 regards also the energetic aspects. The following sizes are determined:

- the flue gas composition,
- the quantity of the flue gas,
- the quantity of the combustion air,
- the temperature of the flue gas.

The large advantage of the program is the flexibility of the possible data. So the elementary analysis of the fuel can be entered or one can the fuel up from different substances build. The integrated table of the substances is expandable, so that you can adapt it to the personal or industry-specific needs.

For the burn necessary the amount of air is computed very variable, after practically arbitrary criteria. You can enter directly the amount of air (as mass flow or flow rate), determine the excess air factor, set the desired quantity (mass flow or flow rate) of the flue gas or the desired oxygen concentration in the flue gas (damp or dry).

When desired the amount of air can be computed in such a way, which adjusts the expected adiabatic burn temperature.

The gas data provided with the program can be stored, which makes the further processing possible with other programs (e.g. HS-SKLAD). As result the user gets an printout with the data of the fuel, the combustion air and the flue gas.

sliding bar. With the bar λ can be adjusted in the borders between 1.00 and 5.00 in steps of 0.01 or 0.10. Each change of the position of this sliding bar releases an immediate new calculation of the flue gas and the amount of air.

In the right part of the window the data of the computed flue gas appear. Still if no flue gas is computed, this part is empty. Otherwise in the upper box the composition of the gas as percentages by volume and in the right column the freight is shown. Among them the quantity is indicated as flow rate in Nm³/h and mass flow in kg/h. One is to remember that the quantity of nitrogen oxides appearing in the flue gas data originates from the combustion air, and not from the burn (see chapter 4). In addition the arising adiabatic burn temperature is indicated.

4 Assumptions

The following assumptions for the computation were agreed upon:

- All elements change completely into the flue gas, if them not when inert ones were entered. A connection of e.g. sulfur, chlorine or fluorine in ash must be considered during the input of the fuel composition, by only the volatile part of the elements proven, and which is defined remainder as inert
- The burn is complete, i.e. as products develop carbon dioxide, water, nitrogen, sulfur dioxide, hydrogen chloride and hydrogen fluoride. The minimum oxygen quantity, who can be supplied to the burn, corresponds to the air number together with the oxygen contained in the fuel $\lambda = 1$. Carbon monoxide or sulphur trioxide cannot develop. The developing flue gases are not loaded with dust. All solids with the burn developed, or with the combustion air into the combustion chamber arrive, are considered as completely separated.
- With the burn no nitrogen oxides develop and no nitrogen oxides are destroyed. The nitrogen oxide quantity contained in the flue gas originates from the combustion air.
- Chlorine and fluorine will change into the flue gas in the form of hydrogen chloride and hydrogen fluoride. In addition an appropriate quantity of hydrogen must be contained in the fuel (the hydrogen in the water considered).
- The quantity of ash resembles the quantity of inert ones, which arrive with the fuel into the burn. The inerts react not with the combustion air and decompose not.
- The Cp-values of the fuel and ash are average values in the appropriate temperature range; the enthalpy of ash and fuel can be computed by multiplication of the temperature and the Cp-value.
- The temperature of the fuel deviates from 25°C, in that the calorific value computed is not substantial (only with fuels, which were provided from substances).

5 Dialogues, help window

Actions will accomplish used dialogues. Data are mostly received, examined and if the desired action can be accomplished, the **OK** Button is released. If yet all necessary data were not entered, or some data are wrong, the **OK** Button is disabled. The text boxes, the wrong data contained are yellow emphasized. Beyond that you can let the errors list by calling the help.

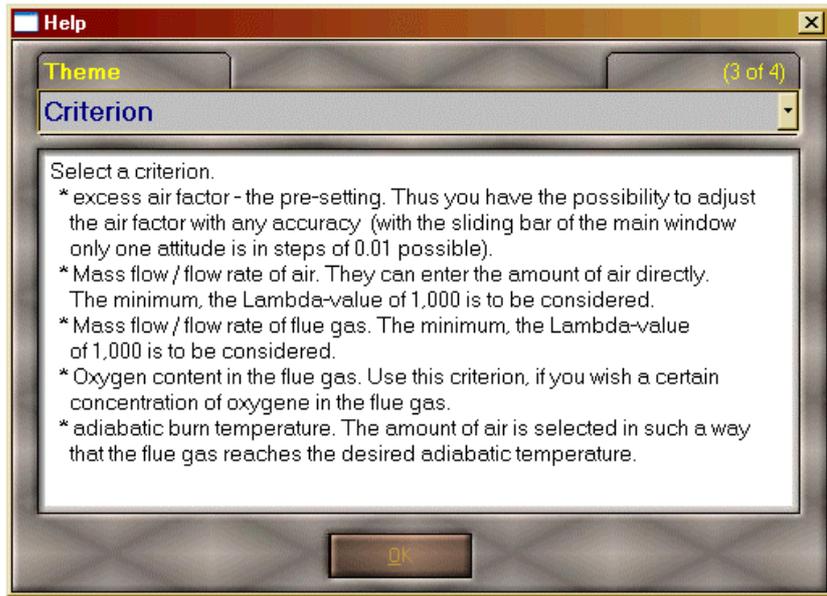


Illustration 2 The help window

The help window consists of a combo box for the selection of the topics, the white text surface, in that the explanations appears and the OK Button to closes the window. If an error were found in the input data, the explanation of the error appears, otherwise the general description of the dialogue. In the combo box you find in both cases all the topics, which are assigned to the dialogue, from which the assistance were called.

6 The menu

The functions of the program are callable over a pull down menu. The menu is partitioned into the topics "Fuel", "Combustion air", "Flue gas", "Print" and "Setup".

6.1 Menu Fuel

The menu steers the input of fuel data in the program. You can enter the data by keyboard and change it, load from a file or store into a file. It exists the possibility to arrange the fuel from substances and add another fuel.

6.1.1 New...

On the screen the dialogue window appears to the input of fuel data into still no data is occupied. Over use of the dialogue you read in the chapter 6.1.2.

6.1.2 Edit...

The data of the current fuel appear in the appropriate input boxes. In the left upper panel the name of the fuel is entered.

Fuel

Name: Natural gas Cap Bon / Tunisia

Composition	Mass.-%
C Carbon	76.98927
H Hydrogen	23.01073
O Oxygene	0
N Nitrogene	0
H ₂ O Water	0
S Sulfur	0
Cl Chlorine	0
F Fluorine	0
Inerts (Ash)	0
Sum:	100.0000 %

Assembled of [Mass.-%]
 65.93 % Methan
 17.5 % Äthan
 9.65 % Propan
 5.45 % Butan-n
 1.47 % Buten-1 (n)

Mass Flow Flow rate
 1126,8 Nm³/h

Adjustment

Upper heating value
 53938,92 ? kJ/kg

>>>

Data for Mass Balance / Data for Enthalpy Balance

Illustration 3 Enter of fuel data

Under the name are input boxes for the elementary analysis of the fuel. Into the boxes for sulfur, chlorine and fluorine will only the portion of the elements be entered, which is to change with the burn into gas, the rest should be classified to inerts.

In the right upper corner one can enter the description of the fuel. If a fuel was provided, from chemical materials this description is reserved automatically with the entered composition.

Among them the quantity of the fuel planned for burn is set. It can be always entered as mass flow. If a fuel was provided from substances, the information is to be determined sufficiently around the standard density and be given to the user the possibility of using alternatively flow rate of the gaseous fuel. Select the appropriate option and enter the number.

The dialogue window puts two balance functions to you at the disposal. The composition of the fuel can be brought by adjustment of the inert portion or proportionally on 100%. Activate the functions by click on the appropriate key in the box **reconciliations**. They are active only if a reconciliation is necessary and possible. Reconciliation with inert is possible only if the difference is smaller to 100% than the inert portion.

Into the input box **calorific value Ho** is entered the calorific value of the fuel in kJ/kg. This input is not mandatory - the burn calculation can be accomplished also without enthalpy balance. If the calorific value Ho is not well-known, you can let the heat value Hu convert into calorific value. Click in addition to the question mark button and enter you the heat value in opening the dialogue.

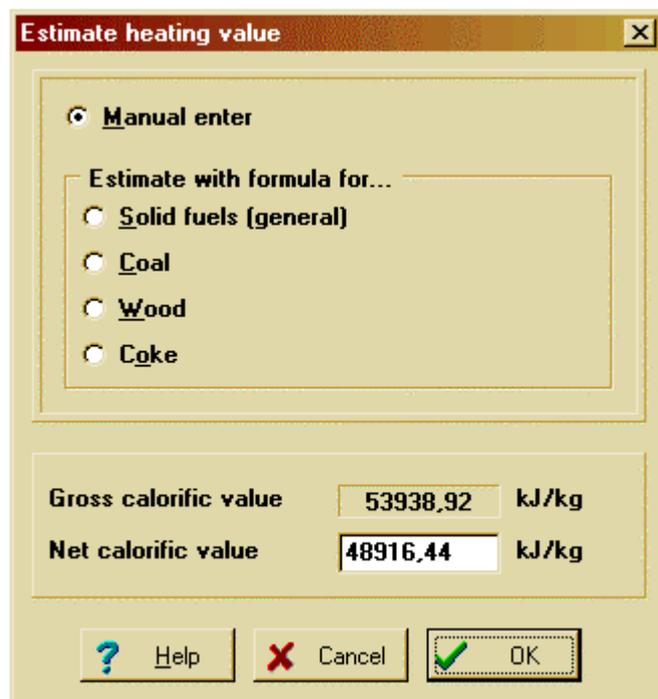


Illustration 4 Input or estimation of calorific value

It takes place a conversion, which is dependent on the composition of the fuel. They know this method using only if the composition input is final already. The dialogue makes possible also the estimation of the calorific values for some classes of the fuels.

If the enthalpy balance is to be accomplished, the program needs except the calorific value also some further data.

By selecting "Data for enthalpy balance" or the Buttons ">>>" you arrive a further side of the dialogue, in which the Cp-values and temperatures are entered or selected of fuel and ash. These data can be entered into the input boxes. It is a possibility to define also classes of fuels to those values to be assigned. So then these values can be occupied automatically by selection of a fuel class from the list. Near a class you select double click simply a position of the list **standard for...**

If the temperature of the ash should be the adiabatic burn temperature, switch the switch on **ash temperature such as flue gas**.

Definition of a new fuel class

- Fill the values for Cp and temperature of ash and the fuel. The data of ash must be entered also if a fuel does not form ash. The value of the inputs has then no influence on the computation.
- Operate the Button "Add standard" and enter the designation of the new class (e.g. "domestic refuse").

6.1.3 Open file...

Activate the function from the menu **Fuel/Open file**. A dialogue window appears for the selection of the files.

6.1.4 Save...

Select from the menu **Fuel** the function **Save**. A dialogue window appears for storing in files.

6.1.5 Assembly...

The program makes possible an arranging of the fuel from chemical substances. Thus the input of the fuel composition is facilitated particularly for gaseous fuels, for which mostly not elementary analysis, but the portions of the gas components is available. During the input of the composition in percentages by volume with the conversion with a molecular standard volume from 22,4 m³/kmol one proceeds. In order to activate this form of the input, you select the option **providing** from the menu **Fuel**. The dialogue window illustrated below appears.

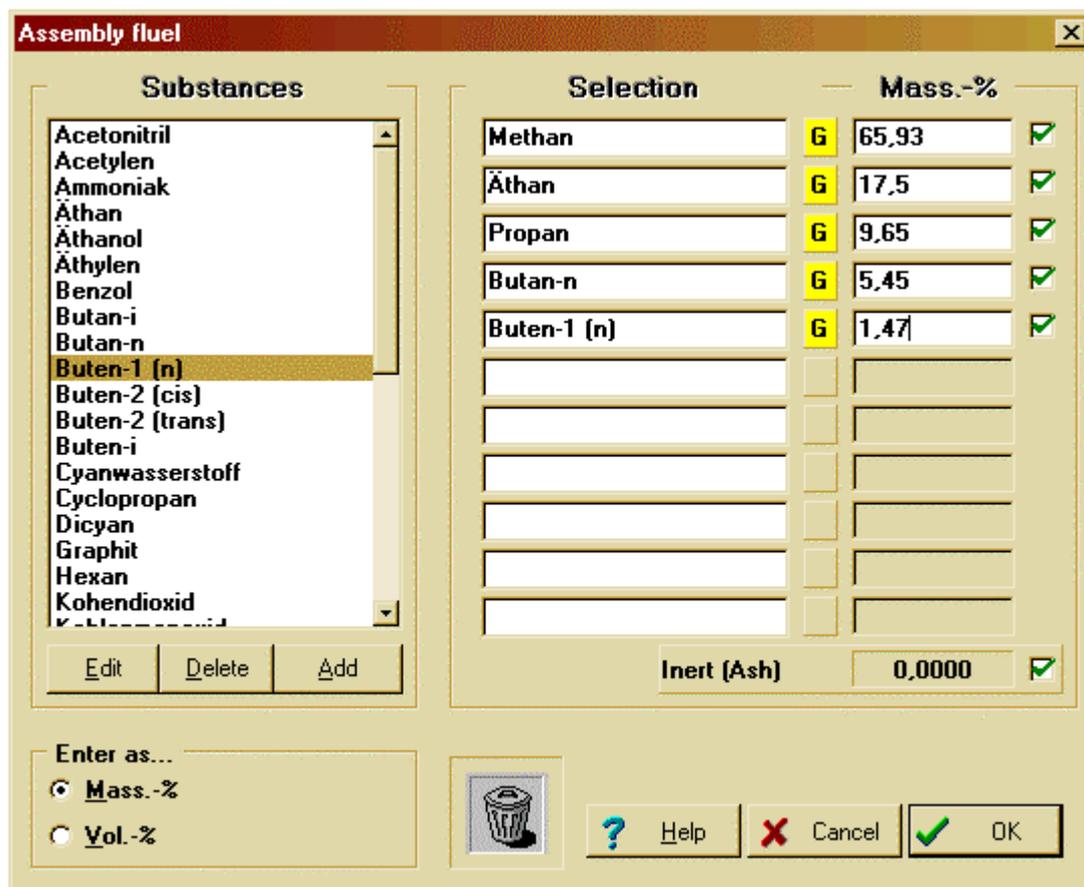


Illustration 5 Provide the fuel from substances

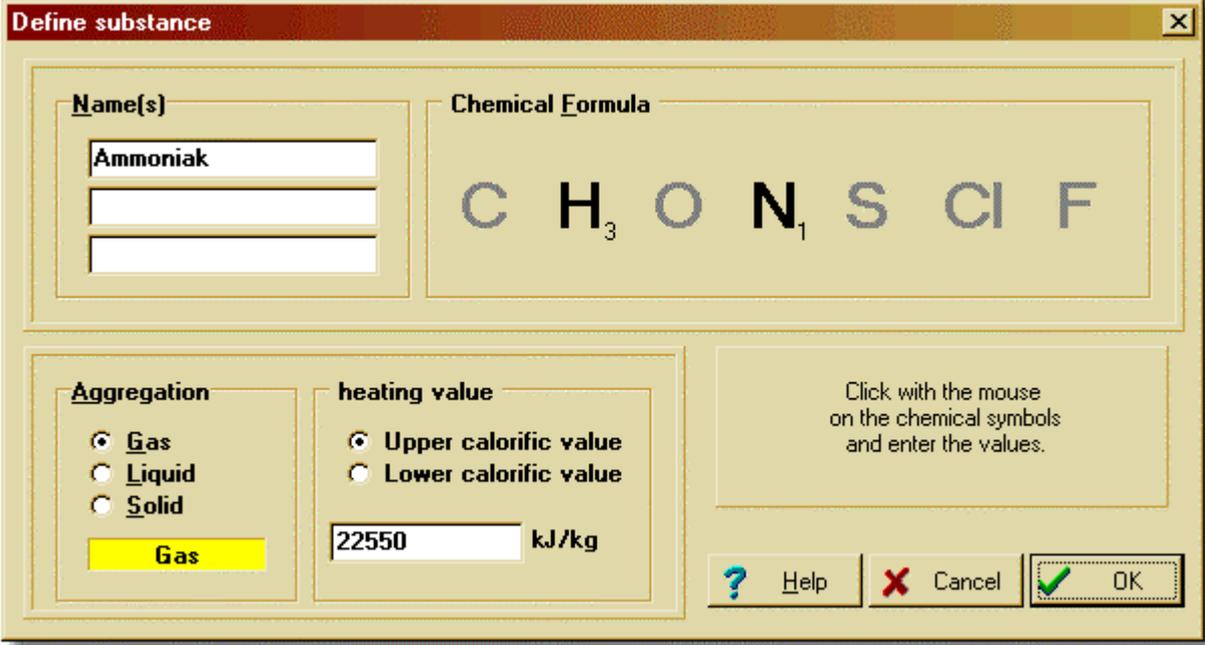
As the first you are to decide whether you will refer your inputs to mass or to volumes. The input as volume % is possible only with volatile materials, so that solids do not stand for any more to the selection. The attitude is made with the radio Buttons in the left lower corner of the dialogue window. A change-over of the option updates the list of the substances the available. In order to select a material from the list, you mark it and pull with the mouse on a text box of the substances. In the text box now the name of the material appears followed of the symbol for state of aggregation of the substance. The cursor is on the appropriate place for portion of the material. Enter the number. If the calorific value of this substance admits is, this is communicated on the right side by an option box with green checkmark. Otherwise there a red cross appears. This material is deleted by taking up a selected material and throwing away into the trash can by the selection.

If the option **Mass.-%** is active, the composition of the fuel is brought automatically by inerts on 100%.

During input of a gaseous fuel there is no ash, so which one must pay attention to it, which results in the sum of the percentages by volume 100%.

Add new substances

Is if a material, which you need for arranging the fuel, not in the list contain, you can it define and to the list take up. In addition the chemical sum formula is needed. Click in the box of materials on the key **Add**. A new window is opened.



Define substance

Name(s)
Ammoniak

Chemical Formula
C H₃ O N₁ S Cl F

Aggregation
 Gas
 Liquid
 Solid
Gas

heating value
 Upper calorific value
 Lower calorific value
22550 kJ/kg

Click with the mouse on the chemical symbols and enter the values.

? Help X Cancel ✓ OK

Illustration 6 Definition of a substance

Designate the substance. They can become appointed up to three names for a substance. At least one name must be entered (into the upper text box). In the list this substance under all will appear later their names. The sum formula of the substance is defined by clicking on the chemical symbols of the elements and entering the numbers. Determine the upper or lower calorific value and the state of aggregation.

Solids can appear only in fuels, whose quantity and composition are mass-referred entered. Materials, which are marked as liquids, can be contained in fuels exactly the same as gases, which mass-referred or are also volume-referred entered. Liquids can be regarded thus in evaporated form as gases. Mark materials, which can be present gaseously as "gas" or "liquid", and substances as solid or liquid, but not when gas or steam of the burn is supplied, as "solid".

6.1.6 Mixing

The program makes a mixing of the fuels possible. In this way then different fuels can be burned together. Also mixtures with the desired upper or lower calorific value can be produced. Activate the menu **Fuel/Mixing**. The dialogue for open a fuel file appears. After selection of the file with the fuel which can be added the following dialogue window appears:



Illustration 7 Adding of fuels

Select the desired criterion. Flow rate is available only for fuels with well-known standard density, i.e. for gaseous or volatile fuels, which were produced with the function supply. The criteria **upper heating value of mixture** and **lower heating value of mixture** are available only if admits the energy contents of the current and the additional fuel are. Before mixing the missing upper heating value can be entered.

6.1.7 Quit HS-FIRE

The last fuel and air data will be stored in the files with the names: "last-f.brn" and "last-f.rgs". At the next loading procedure the data are read from the files. For this reason you are not to delete the files, because they are necessary for starting the program.

6.2 Menu Combustion air

The menu steers the input and a storing of the air data. You can enter and change the data by keyboard, load from a file or save into a file.

6.2.1 Edit...

On the screen the dialogue window appears to the input of air data. The data of currently used air appear in the appropriate input boxes. With the input mask only a simplified composition input is possible, i.e. you can only enter the main components of air in this way. The pollutants are not considered. For input of air is sufficient yet. While the percentages by volume are entered by oxygen, carbon dioxide and water, reconciliation with nitrogen takes place. When

typing you must only make certain that the sum of the three entered components does not exceed 100%. If a gas is loaded in that pollutants contained was, it will lose the pollutants after use of the option **Combustion air/Edit** and will have only in the dialogue window indicated and with nitrogen the composition brought on 100%.

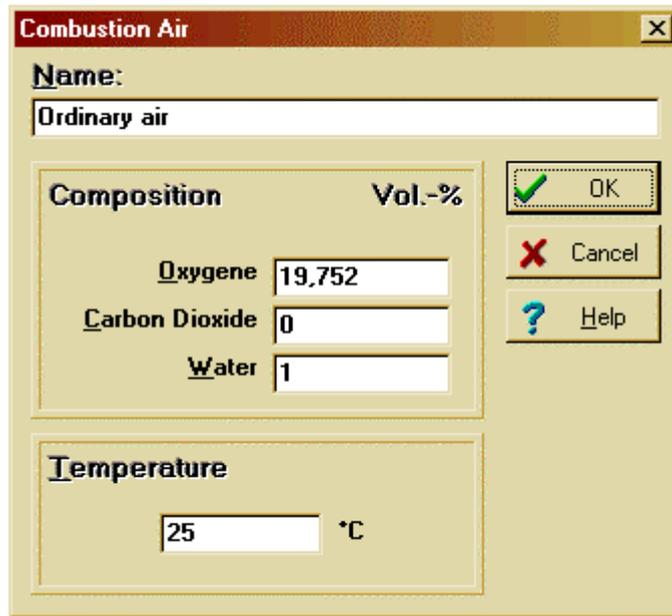


Illustration 8 Input of data of the combustion air

6.2.2 Open and save of data

All file operations are identical in the use to appropriate operations for fuels. The files have this time the ending ".rgs".

6.3 Menu Flue gas

6.3.1 Compute...

For the computation of the combustion the program needs now information about the quantity of combustion air. You can define the quantity in different way. Directly on the main form of the program an air excess factor with the mouse can be adjusted. In the box for amount of air (down in the middle part) is a horizontal slider. With the slider a fast attitude of the excess air factor with the accuracy of 0.01 is possible. The range of adjustment of the slider extends to values from 1.00 to 5.00.

Another, more flexible method is the use of the option **Compute** from the menu "**Flue gas**". In the panel on the left side of the dialogue window you find all possible criteria of the amount of air regulation. Pre-setting is Lambda factor. The option: **adiabatic comb. temperature** is active only if admits all data necessary for the enthalpy balance are. Select the desired option by clicking to the appropriate radio Button.

Over the input box then a number appears depending upon criterion then it announces the minimum or maximum of the valid input. So long you did not enter any valid number into the input box, the **OK** button is disabled. Enter the desired value. Among them still another input box finds in which one data to the amount of fuel update it can. Normally appears there to the quantity specified during the fuel input as mass flow. If you want to define this quantity as flow

rate, select the option **Flow rate** and you enter the number. The possibility flow rate to define exists only with fuels, which were entered as mixture of substances.

Illustration 9 Determination of the amount of air

If the enthalpy balance is not to be computed, switch the switch "**Don't compute temperature**" on.

If the flue gas is computed, the results are shown. On the right side the composition of the gas appears in volume % and the freight of the individual products of combustion. Among them the quantity of the flue gas as mass flow and flow rate. The determined quantity of the combustion air will down appear in the middle box. If the adiabatic burn temperature was computed, then also this is indicated under flue gas data.

6.3.2 Save...

The data of the flue gas are exactly the same stored like the air data. The operation and the structure of the data in the developing file are identical.

6.3.3 Launch HS-SKLAD

This option arranges the transmission of the flue gas data to the program "HS-SKLAD" to the more exact evaluation. The program HS-SKLAD is opened and loaded with the flue gas data. This menu option is active only if the flue gas data are present (after a computation) and the program HS-SKLAD is installed in the same directory as HS-FIRE.

6.4 Menu Print

This menu is active only if flue gas data are present, i.e. after a computation. The printout consists of one side and contains all information, which would be necessary for repeating (reconstruct) the combustion calculation.

The composition and quantity of the flue gas are spent.

6.5 Menu Setup

Those in these menu available functions make the attitude of the Dongles possible and spend information about the program.

6.5.1 Settings...

Here you can select the language and the system of units. Please read more details over the use in the chapter 7 "Units system".

6.5.2 About HS-FIRE ...

Here you get the information about the version of the program, as well as the contacts of our engineer's office.

7 Units system

This program enables working in the units of international SI system of measure, and also in the alternative, optionally defined by the user, system of units. It is possible to switch between these systems during work.

CAUTION !

The alternative system of measure units is defined by the user, therefore:

the user himself is responsible for the correctness of the recalculation definitions!

This refers also to the optional conversions already included in the newly installed programs. The user is obliged to check its correctness, before he starts using it!

Especially, the standard gas condition may be differently defined, therefore it recalculates into the standard in the SI system (0°C, sea level) can be different.

The recalculation definitions are used together by all the programs. The changes are made as follows:

Hit menu **Setup/Settings...** and generate the settings dialogue. Here the units system can be chosen. The changes are made after pressing **Edit...** button. Then, the window with the defined recalculations table appears:

Definition of conversions							
Property	SI	Alternative	Factor	Offset	Prec. SI	Prec. alt.	Inv.
Temperature	°C	°F	1.8	32	2	2	.FALSE.
Pressure (big)	bar	psi	14,50377	0	2	2	.FALSE.
Pressure (small)	mbar	psi	0,0145038	0	2	5	.FALSE.
Length (big)	m	ft	3,28084	0	3	2	.FALSE.
Length (small)	mm	inch	0,0393701	0	1	2	.FALSE.
Length (very small)	µm	micron	1	0	1	1	.FALSE.
Mass (very small)	mg	mg	1	0	1	1	.FALSE.
Mass (small)	g	g	1	0	1	1	.FALSE.
Mass	kg	lbs	2,204623	0	1	1	.FALSE.
Area	m²	ft²	10,76391	0	3	2	.FALSE.
Mass flow	kg/h	lbs/hr.	2,204623	0	1	1	.FALSE.
Density (liquid)	kg/m³	lbs/ft³	0,062428	0	1	1	.FALSE.

Illustration 10 List of units recalculations

After marking the row and using the button **Edit...** the selected recalculation can be edited.

Temperature
OK

SI system: °C

Alternative: °F

Factor

1 °C = 1,8 °F

Offset: 32

Reverse

Fractional digits

SI: 2 Alternative: 2

Test

0 °C = 32,00 °F

32 °F = 0,00 °C

Illustration 11 Defining the recalculation

This example illustrates the definitions of temperature recalculations between "°C" and "°F". At the bottom of the dialogue, there can be tested the correctness of the entered data and set the number of digits after comma.

8 License agreement

Application range

This program can be used on the optional amount of computers within the company. Installation in the networks and the simultaneous installation on many computers of this company is allowed. The amount of simultaneously used licenses is regulated by the purchase of dongles or the hire contracts made.

The subject of the contract

This program is the work protected by law in the meaning of the intellectual property law. The rights to this program belong to "Ingenieurbuero Samoticha fuer Verfahrenstechnik". The indication of the author included in the program shall not be removed or changed. The subject of the contract is this program, its description and any other appendices written and the materials included in files. These are further called "software".

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