

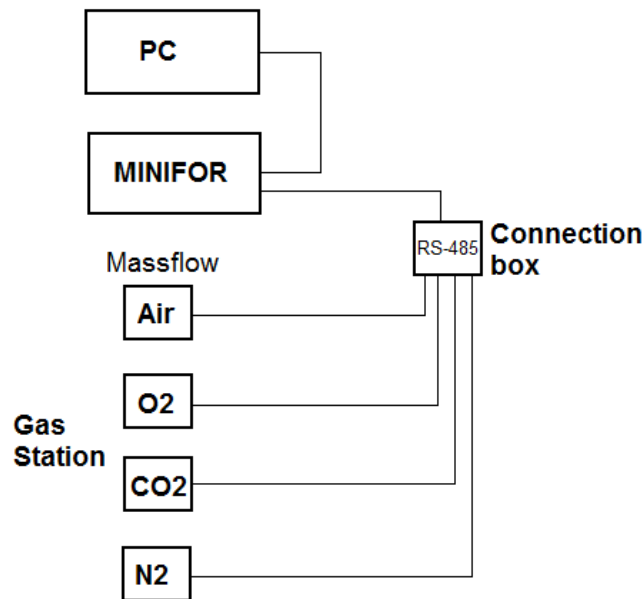
# MINI-4-Gas automatic gas mix software – User guide for configuration of the gas station

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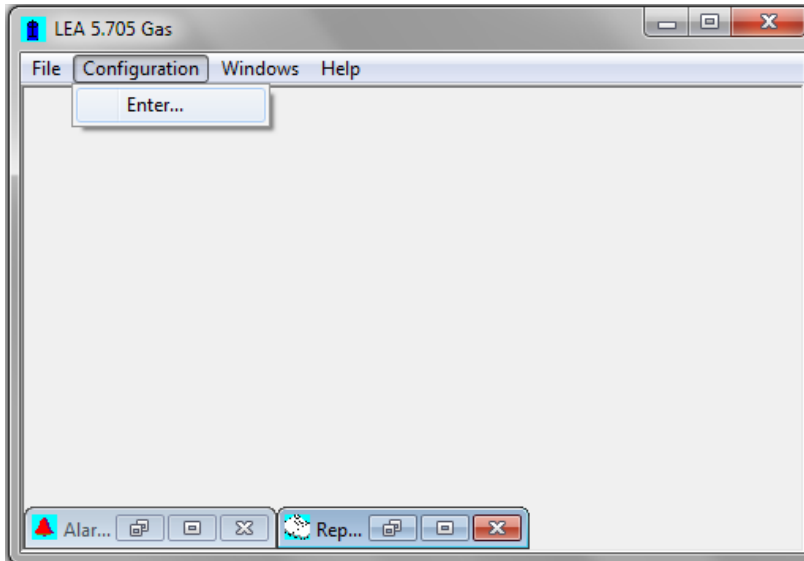
## 1 How to configure the software

### 1.1 RS-485 connection



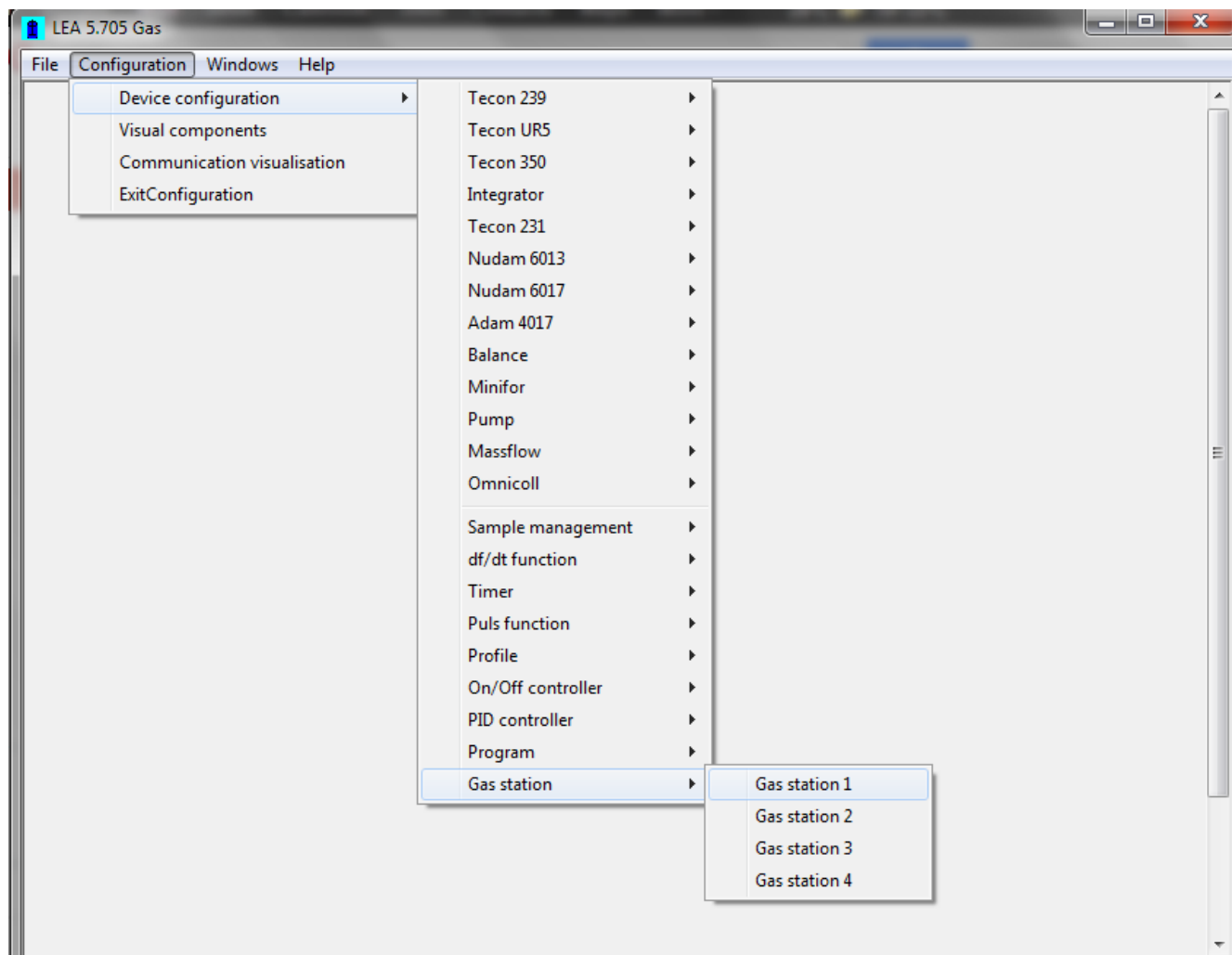
## 1.2 Gas station configuration

First enter in the configuration mode (menu Configuration, submenu Enter).



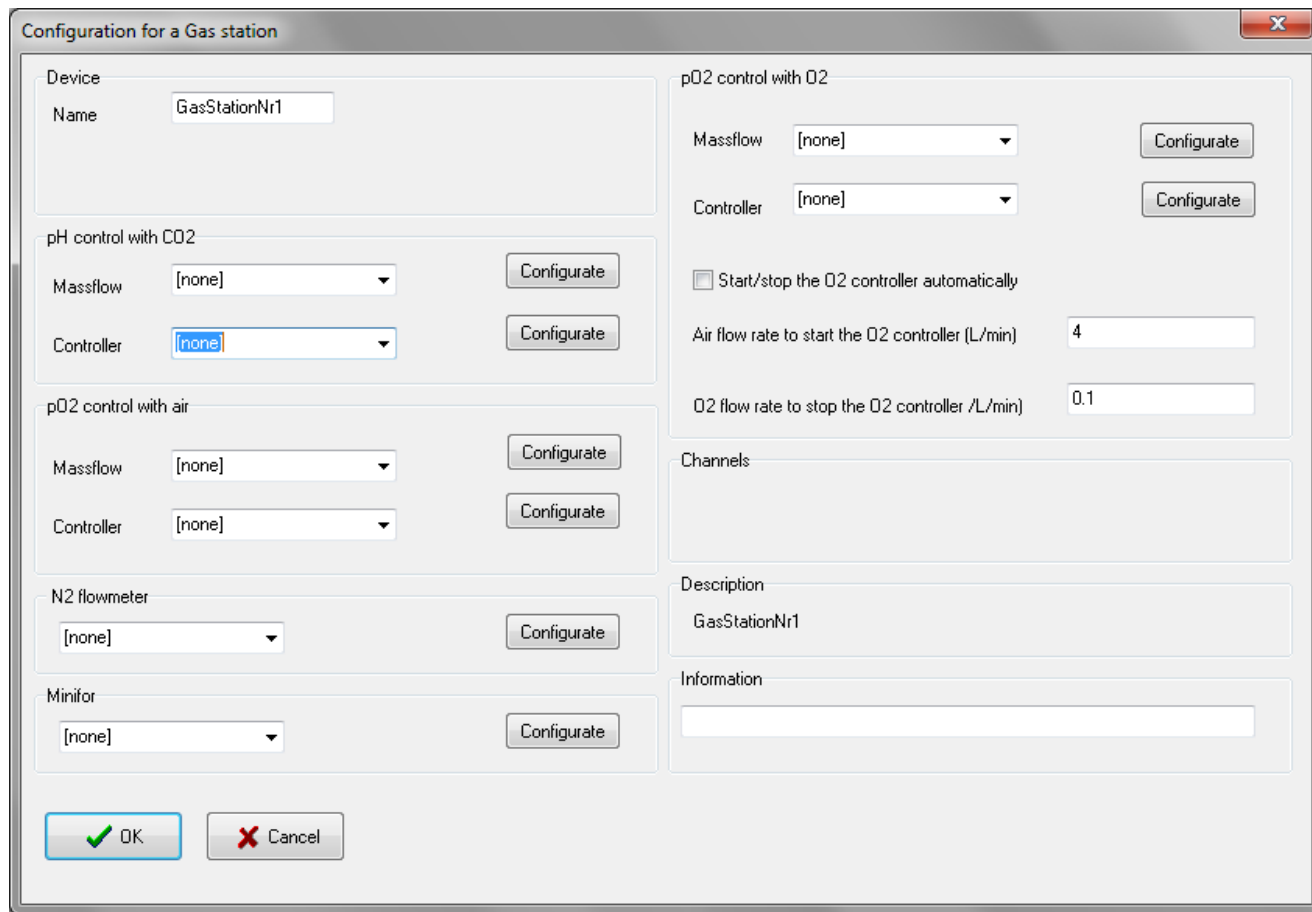
The password is 'lea'.

Then choose in the device configuration menu, the submenu Gas Station 1 (the software can manage 4 different gas stations). In the software, a gas station is composed in one to four Massflow and one fermenter.

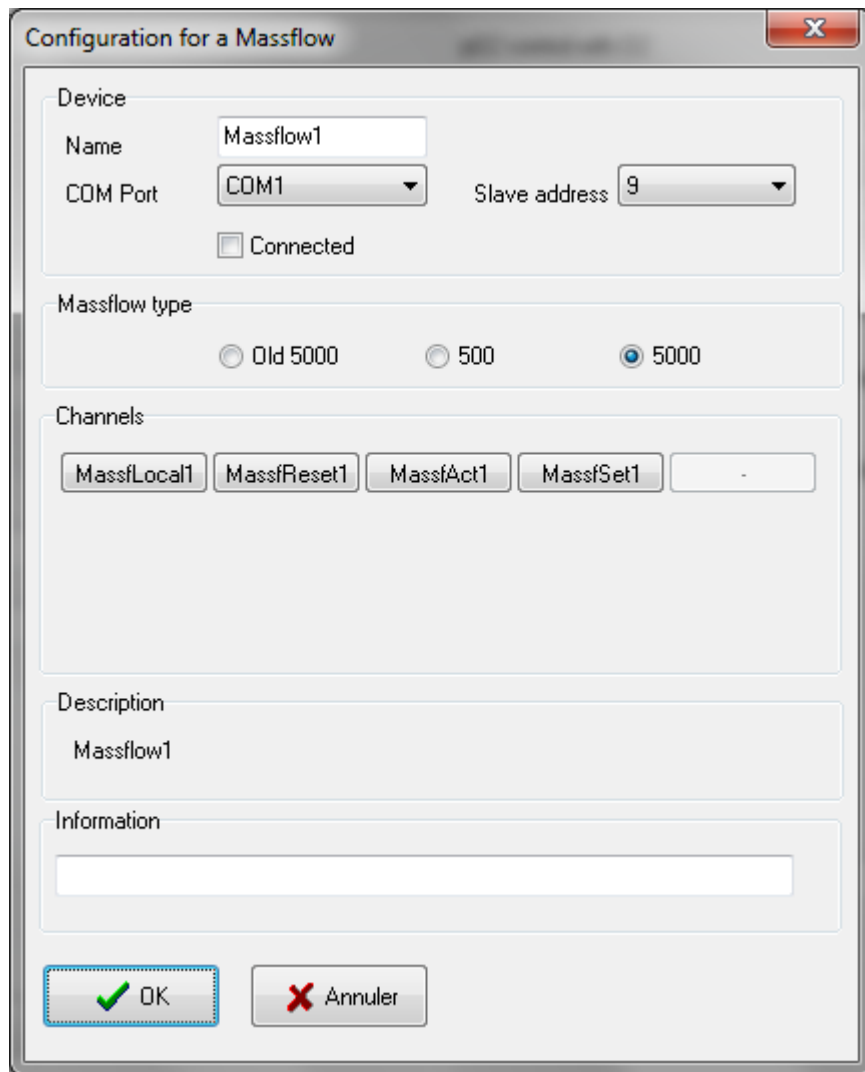


With this configuration window you can choose the devices, like mass flow, fermenter that need to be controlled by the software. The controllers are the software PID controllers.

Once the massflow, fermenter, etc and PID controller in the list are chosen, you can configure them. When the desired device is selected from the menu, a new configuration window will appear.

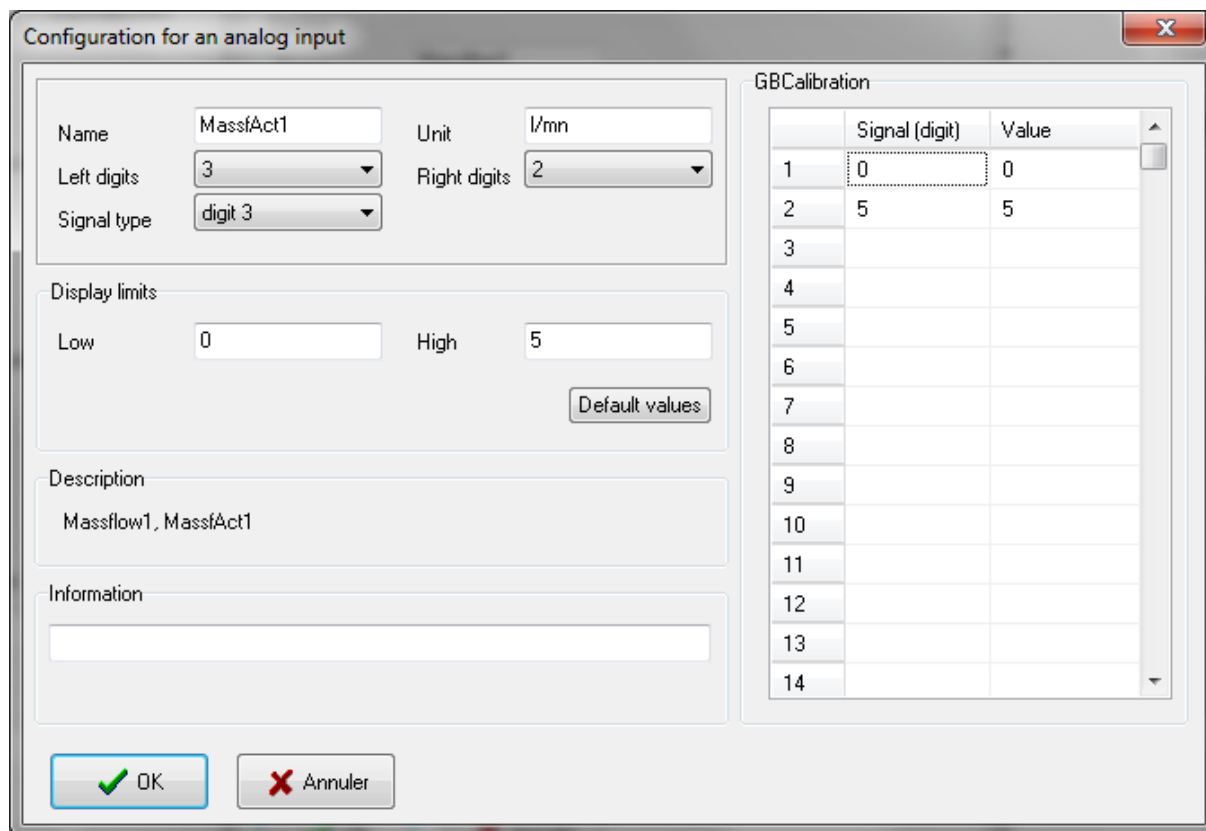


For example: Choose Massflow1 for the pH control with CO2 in the Massflow list. And then press the 'Configure' button. A new window will appear for the Massflow configuration.



You can select the COM Port, the address and the type of the Massflow that you are using. Don't forget to select the 'Connected' option. The communication with the massflow will start when you close the window with the OK button.

Press the MassfAct1 option (actual value for Massflow 1) on the configuration window.

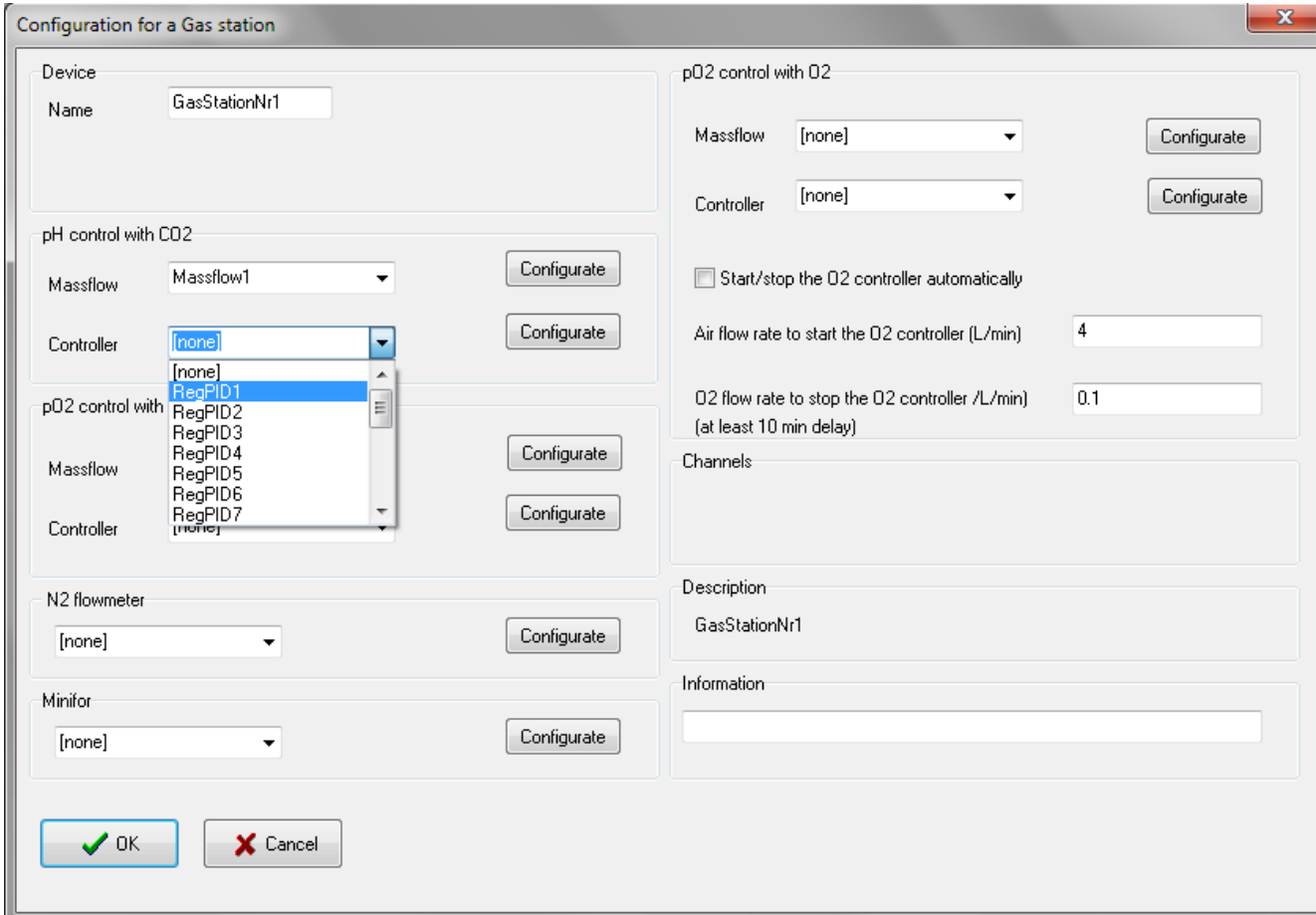


It could be interesting to change the default name for the measurement and set point values. It will be easier to follow the channels in the trends.

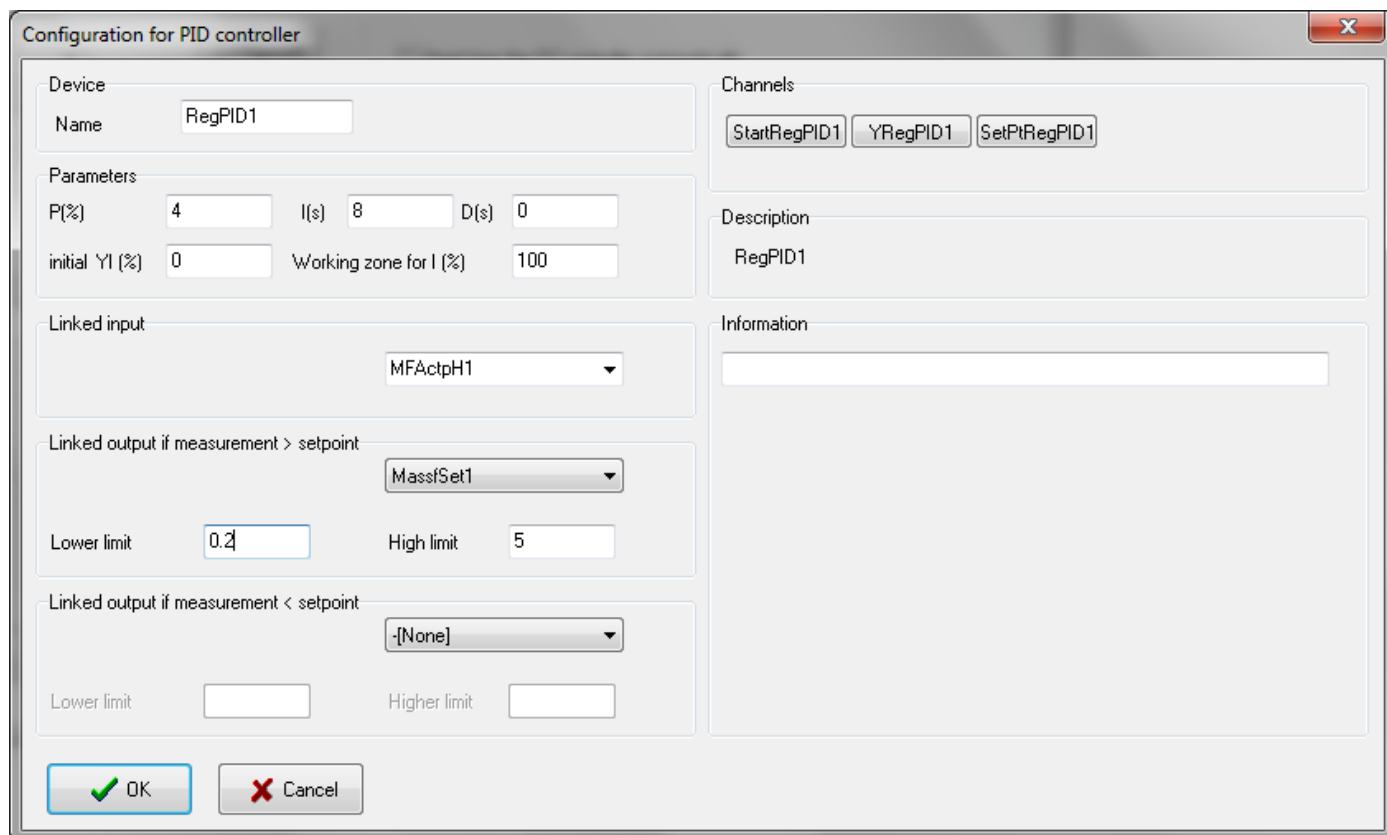
For example: Rename MassAct1 to MassCO21. This is the channel name. You can only use alphanumeric characters. The same can be done with set point, replacing MassSet1 with MassSetCO21.

PID controller for the Massflow can be configured now.

Choose a PID controller in the list, may be the one first in the list, RegPID1.



Then click the configure button.



Enter the PID parameters, for example P=4 and I=8.

Choose then the fermenter pH measurement channel, 'MFAcTpH1' in the 'Linked input' list. Then, choose the set point channel of the CO2 Massflow (here it is 'MassSet1') in the field 'LinkedOutput if measurement > Set point'. Because the massflow should inject CO2, if the pH measurement is higher as the pH set point. If a minimal CO2 flow rate is needed, you can enter the value in the field 'Lower limit'.

The configuration window can be closed with OK.

The same steps can be done for the Air Massflow and the O2 Massflow. We had good results with P= 6 and I = 16 for the air controller, and P=80 and I = 20 for the oxygen controller.

### **Tips and tricks:**

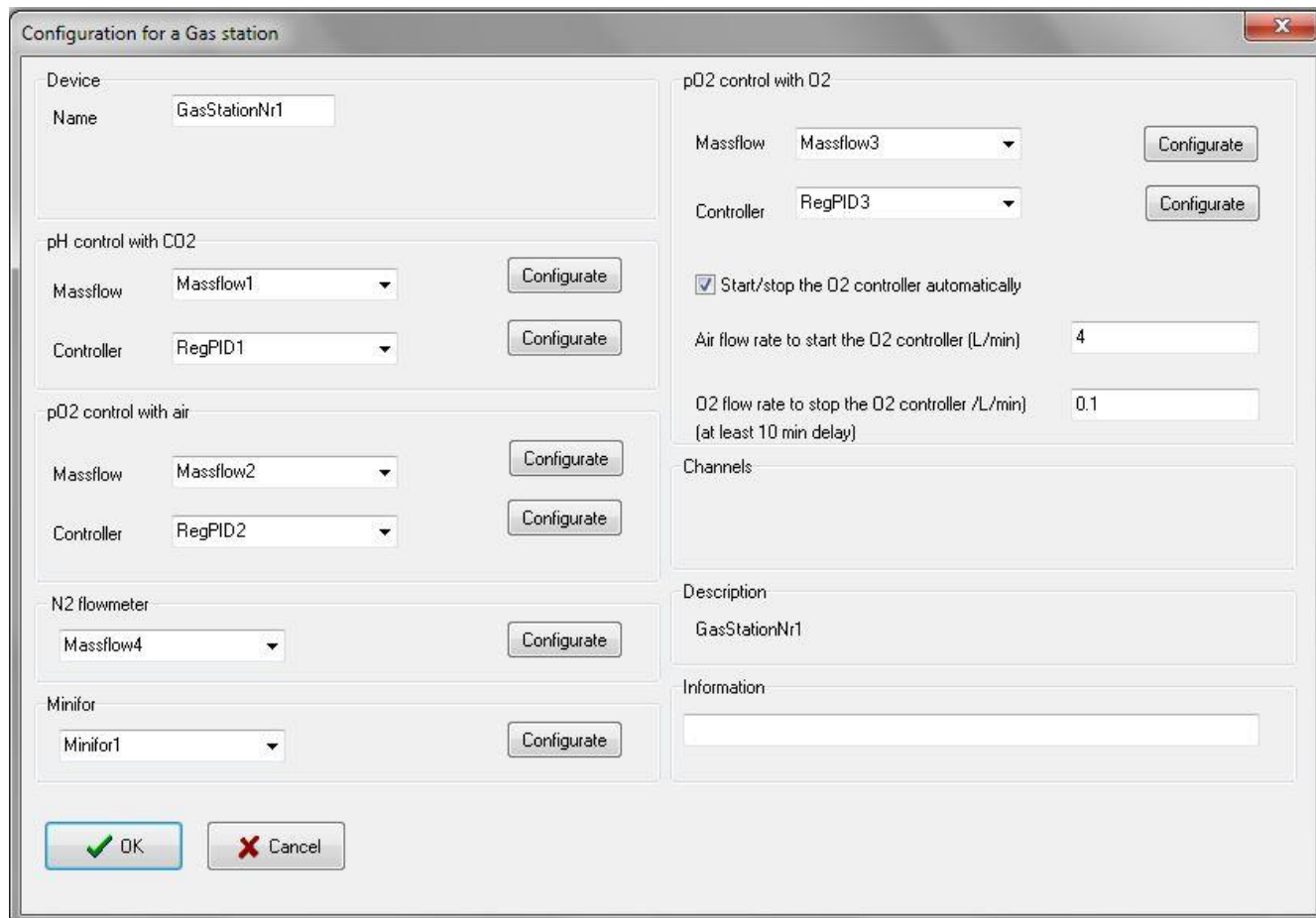
*At the beginning of the culture, the O2 consumption is very low, there is no need to add oxygen. During the growth phase, the oxygen demand will gradually grow and the controller will increase the air flow rate to maintain the pO2 value at the set point.*

*At a point, the air controller will have difficulties to maintain the oxygen level in the vessel. The user can start the O2 controller manually, but it is also possible to start it automatically. We need a condition to start it. This condition is a reached air flow rate. Enter the value of the air flow rate at which the O2 controller should start. It is important to know that, when the oxygen controller starts the air controller will stop and the air flow rate stay at its last value (default value is 4 L/min in our example).*



*At the end of the culture, the oxygen demand will decrease. You can enter the flow rate conditions to stop the oxygen controller and start the air controller again. The oxygen controller will stop. If you want to start the oxygen controller automatically, you need to check the box 'start/stop the oxygen controller automatically'.*

*In some cases, you may like to work with a fixed total flow rate. The controllers change the CO<sub>2</sub>, air and O<sub>2</sub> flow rates depending on the measurement values and set point values. You can use a Massflow controller (number 4) to add nitrogen to maintain a fixed total flow rate (nitrogen flow rate = total flow rate set point – CO<sub>2</sub> flow rate – air flow rate – O<sub>2</sub> flow rate). You can configure this mass flow like the others.*



Now the last point is to select the fermenter for which the gas station has to work.

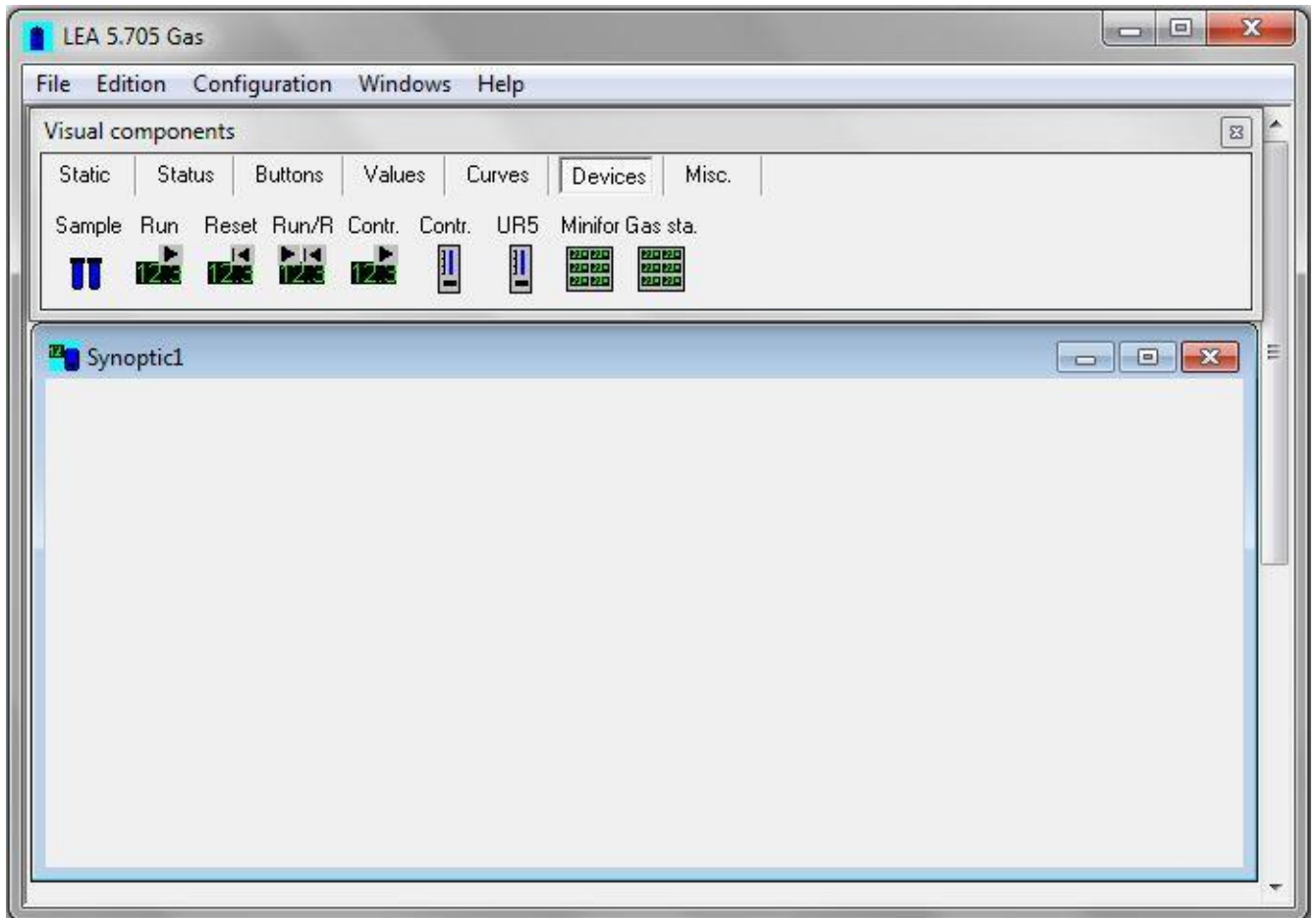
Choose the fermenter in the list 'Minifor'- You can also configure the fermenter by using the button on the right, but the most of the time the fermenter will be configured using the configuration menu.

It is important to visualise the gas station on the screen. When the parameter is changed in the configuration window, you should choose the gas station again (pop up menu) in the visualisation object. If you forget it, the changes will not appear in the visualisation object.

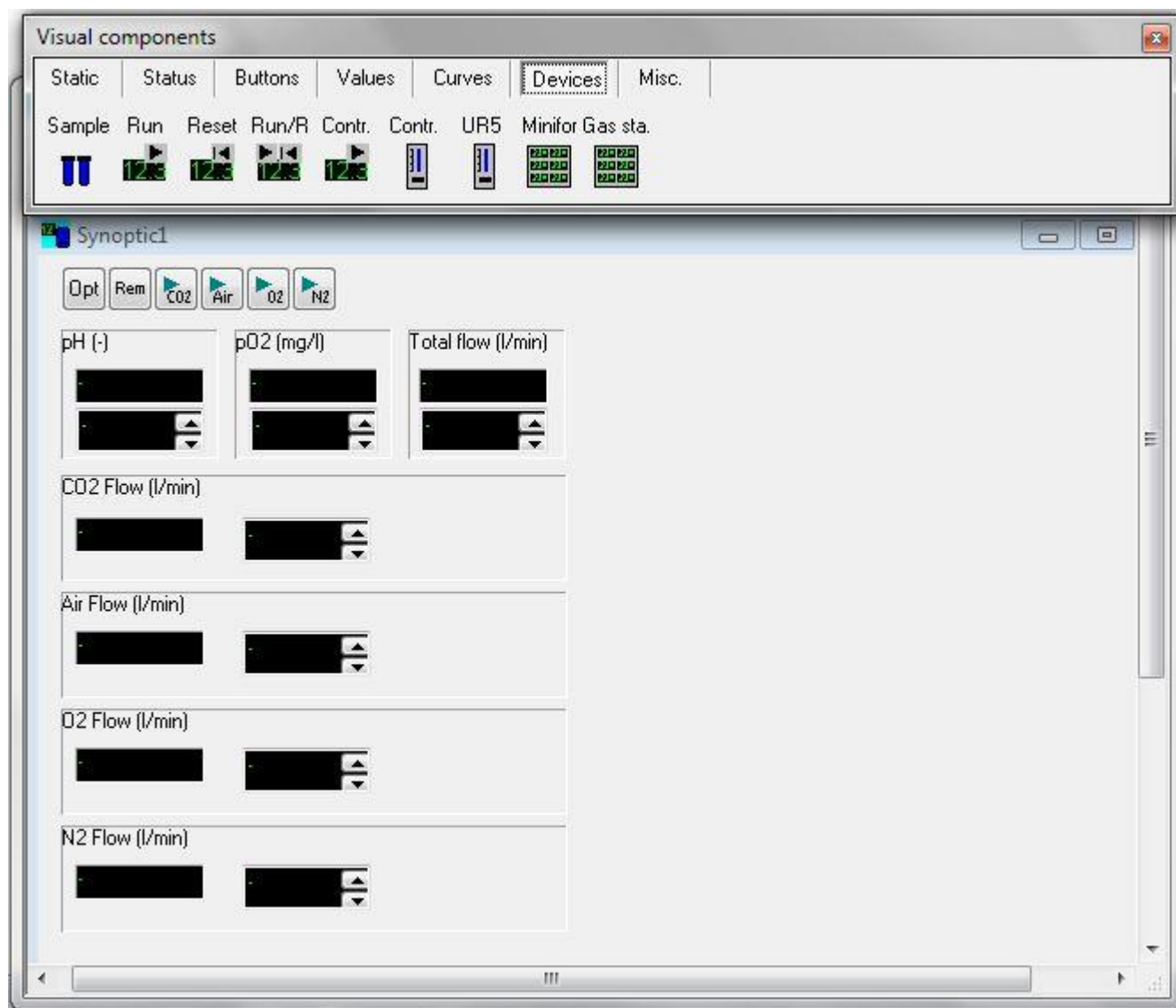
### 1.3 Visualisation of the Gas mix parameters

To display the gas station on the computer screen,

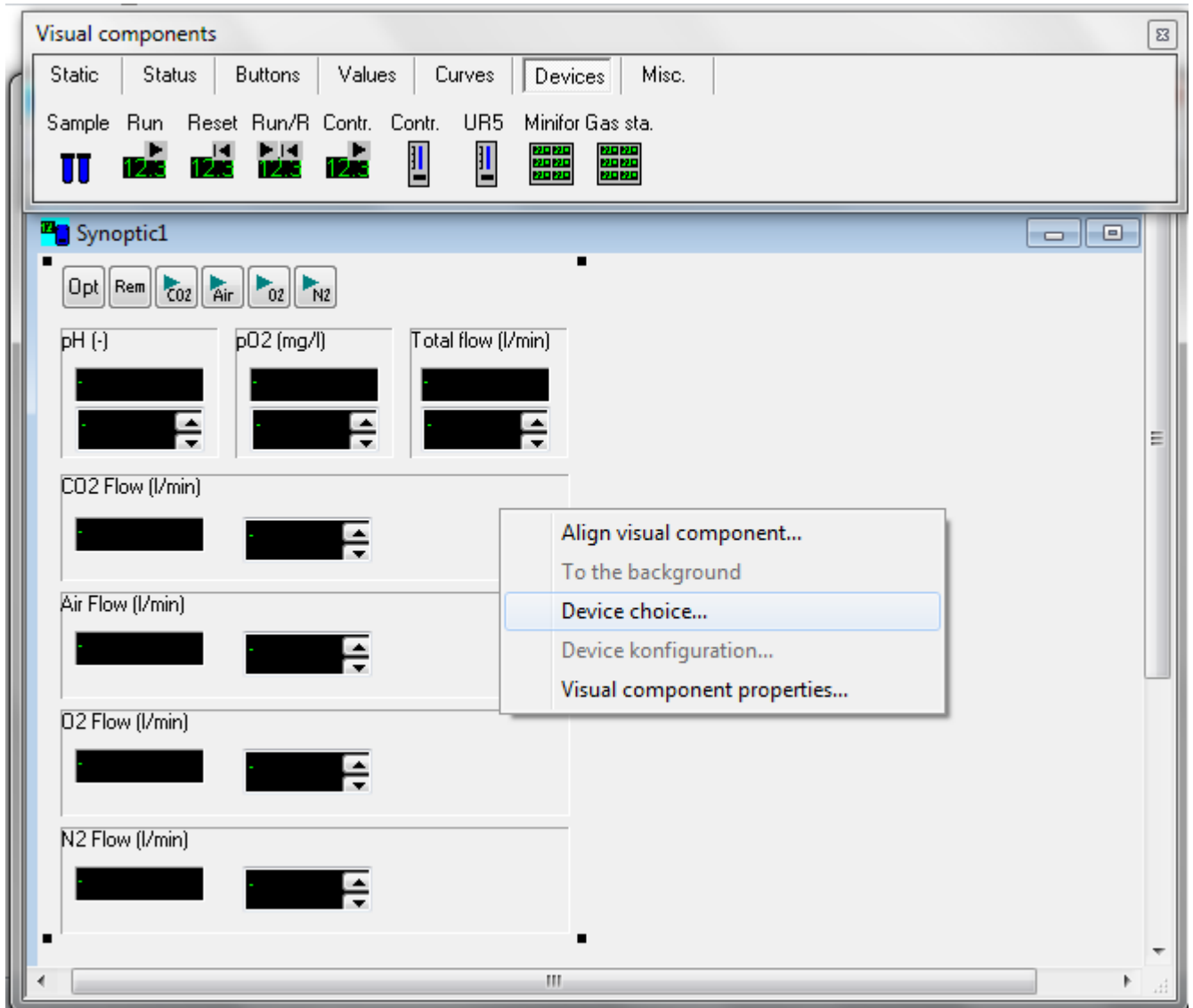
1. Enter in the configuration menu and choose the submenu 'visual components'. A new window with the visuals will appears. And then choose the submenu 'New' under the main menu 'Windows'. A new synoptic window will appear into which the visual components has to be placed.



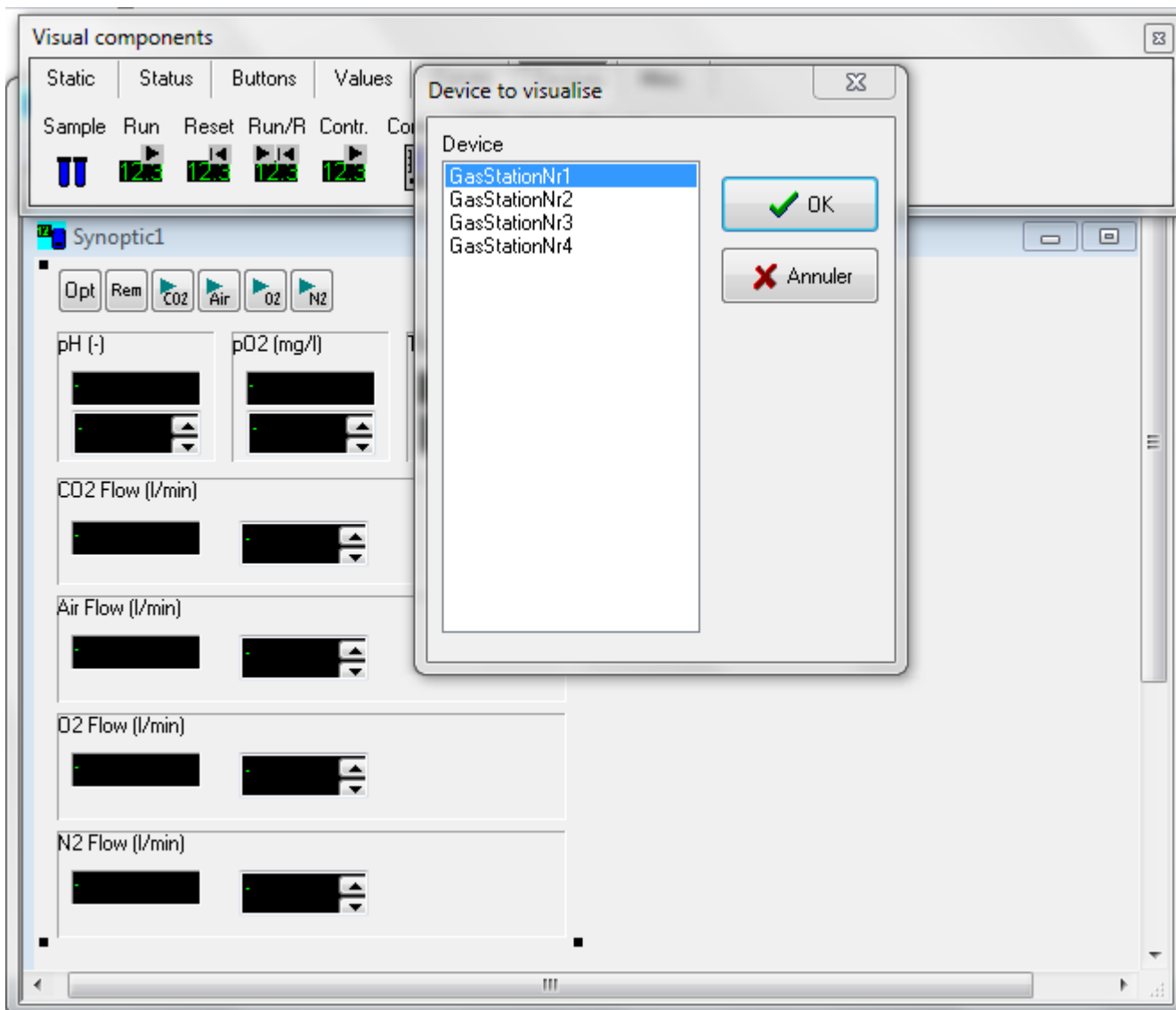
2. Choose the 'Devices' option on the 'Visuala components' window. Click the 'Gas Sta.' option and click the cursor on the 'Synoptic' window



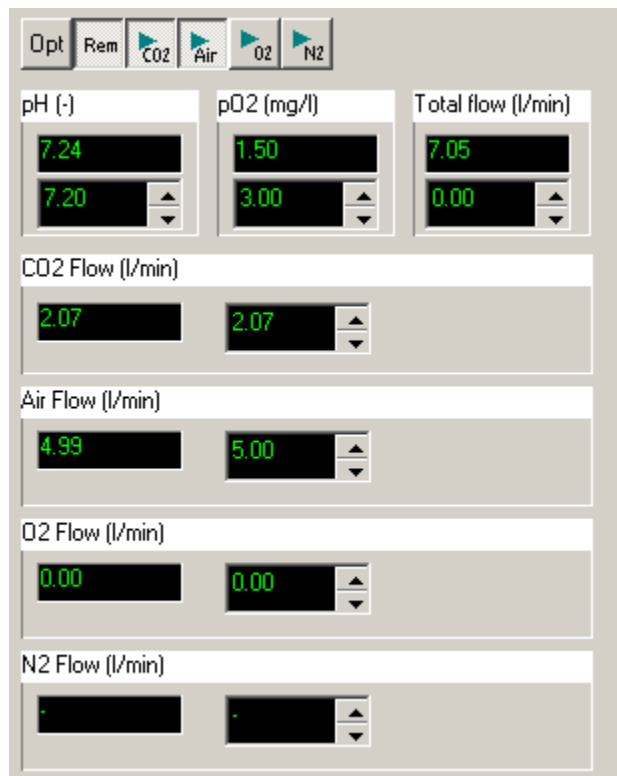
3. Right click on the Gas sta. component and click the device choice to choose the Gas Station.





4. Choose the Gas Station that you have configured.





5. If an element is changed in the configuration, this step must be repeated. So that the configuration changes in the 'gas station device' are also effective in the visual component.




 Remote button. It is for controlling the set points of the parameters in the fermenters, Massflows remotely from the PC.

 CO2 controller. Press this button to start the CO2 controller. If the button is up, you can change the flow rate manually.

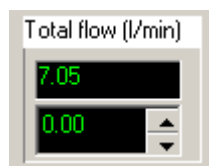
 Air controller. Press this button to start the air controller. If the button is up, you can change the flow rate manually.


 Oxygen controller. Press this button to start the oxygen controller. If the button is up, you can change the flow rate manually. The air controller can also start the oxygen controller depending on the settings in the configuration

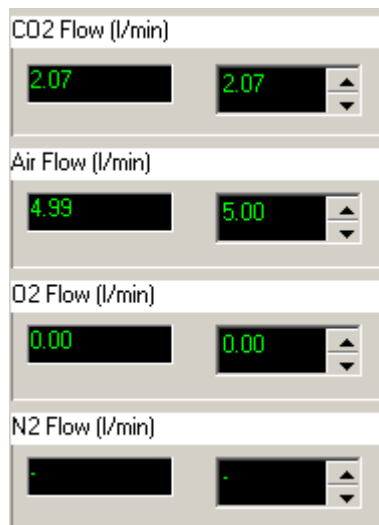
 Start/stop the calculation of N2 flow rate to work with a fixed total flow rate



pH and pO2 values. They are the same as on the fermenter panel.



total flow rate of the four Massflow. If the button  is down, the gas station will complete the 3 other gases with nitrogen.



Set point and measured values for the 4 Massflow. If the corresponding controller button are up, you can enter the flow rates manually.

## 2 Results

The software has been tested under real time conditions of the experiment with CHO cells and fixed air flow rate.

Aeration: head space, with one entrance for oxygen and air together and one entrance for CO<sub>2</sub>.

pH set point=7.2

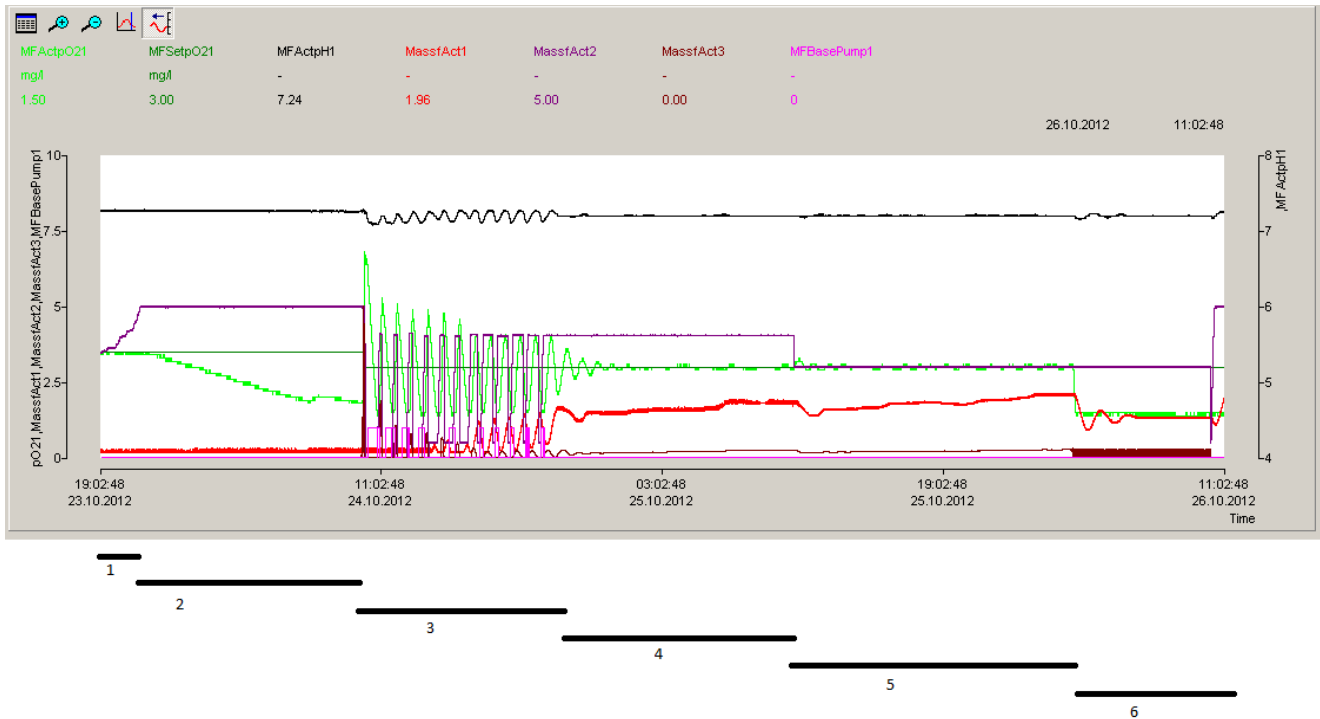
Temperature set point = 37 °C

pO<sub>2</sub> set point = 3.5 mg/L

Massflow 1= CO<sub>2</sub>, minimal value = 0.2 l/min

Massflow 2 = air, minimal value = 0.5 L/min

Massflow 3 = oxygen



**Phase 1:** Air controller alone. The pO<sub>2</sub> stays fix at 3.5 mg/L and the air flow rate increases.

**Phase 2 :** During the night, the maximal flow rate of 5 L/min is reached and the pO<sub>2</sub> decreases.

**Phase 3:** Configuration modification, oxygen controller on automatic mode with starting condition air flow rate = 4 L/min and stop condition oxygen flow rate= 0.1 L/min. pO<sub>2</sub> set point = 3 mg/L. the O<sub>2</sub> controller starts automatically and a few minutes later the pO<sub>2</sub> increases drastically. The measured pO<sub>2</sub> is higher as the set point and the oxygen controller reduces the oxygen flow rate. When the flow rate reaches the value of 0.1 L/min, the oxygen controller is stopped and the air controller is started again (and close also the air...).

The measured pO<sub>2</sub> decreases and under a value of 3 (set point) the air flow rate increases again. When the airflow rates reaches the value of 4, the gas station stops the air controller and starts the oxygen controller again, and the cycle start again...

This phase has been used to adjust the PI parameters of the oxygen controller. Even the choosen parameters make the controller very ,slow', it was not possible to stop the permanent switch between the air and the oxygen controllers. These oscillation are probably responsible also fort the pH changes.

**Phase 4:** The oxygen consumption is probably sufficient to keep the oxygen controller working alone. There is a good pH control (set point 7.2) pH and the CO<sub>2</sub> flow increases slowly. The O<sub>2</sub> flow rate increases also and the pO<sub>2</sub> control works well.

**Phase 5:** Manually change of the air flow rate set point 4 -> 3 L/min to see if the controller can adapt to this new value and to reduce the oxygen flow. The CO<sub>2</sub> and O<sub>2</sub> controllers reduce their corresponding flow rates.



**Phase 6:** The oxygen bottle is empty and the pO<sub>2</sub> drops to 1.5 mg/L. The aeration is made only with the fix 3 L/min air flow rate.

### 3 Conclusion

At our condition (aeration by head space), the pH controller seems to work well. In stationary phases (without big changes in set points, gas flow rates...), the pO<sub>2</sub> controllers do their work quite well.

It seems to be important to find other conditions for the automatic start of the oxygen controller. Adding a time delay of 10 minutes to stop the oxygen controller could solve the problem.

The air controller could also be improved. It shouldn't initialise the air massflow at 0 when it starts after the oxygen controller stop.



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