

## 1 Software installation and update process

The 2Mix software .exe file is native windows application type, so it does not require installation process for itself, and it does not rely on any supporting frameworks (such as .net, c++, java, etc. redistributables), so there is no download and installation for those either.

To “install” the 2Mix software, simply download the .exe file to your preferred location and run it. Windows prevents processes and applications from writing into the Program Files folder, so do not place the 2Mix.exe there, as the program will want to write configuration files and usage logs to the disk, and the default location is under the folder where the program is ran from.

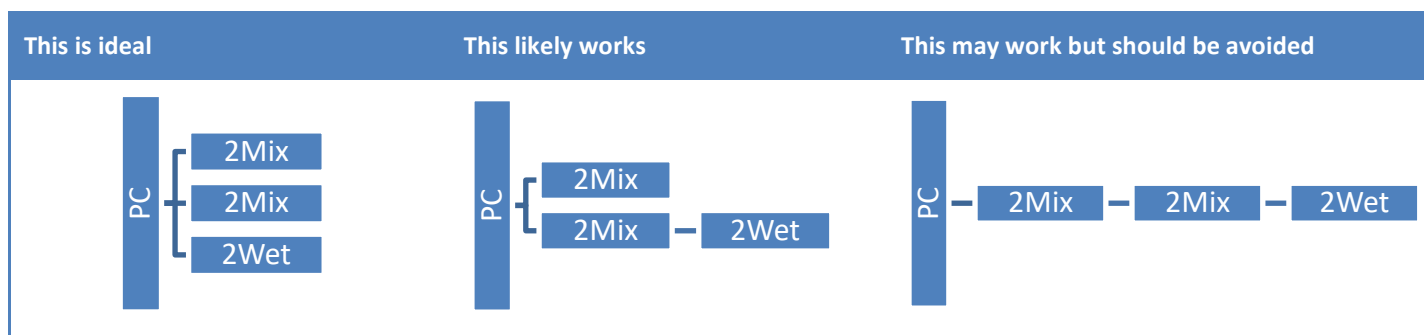
When updating to a new version, it is advised to first make a new folder to archive the previous version. For example “Old-2Mix-2024-02-18”, and then place the old .exe file in that folder. This way, in case the new update has a problem, the previous version can be easily restored and used (copy it back to the main application folder) until the problem with the new update is solved.

## 2 USB drivers

When connecting the instruments to a PC, the COM port drivers are usually automatically recognized and installed correctly by Windows. In case they are not, on IT department managed computer, old versions of Windows, or for some other reason, find the right VCP type drivers from <https://ftdichip.com/drivers/vcp-drivers/>

## 3 USB connections

The depth of USB daisy chain has limits, as each new hub needs to supply power to the hubs downstream. Often the USB ports on the exterior of a computer already come from an internal hub. The build quality of the internal hub and it’s drivers are main determining factor for the possible depth of the daisy chain. Overall it is advised to avoid deep daisy chains when possible, and in case the PC lacks sufficient USB ports to parallel connect to all devices, acquire high-quality, externally powered USB hub and connect all 2Mix and 2Wet devices directly to that hub. This keeps the depth of the USB network to a minimum.



## 4 Rearranging the form

The screenshot shows the software interface with a top bar labeled 'Time, m'. Below it, there are two main sections: 'Available devices' and 'For selected device'. The 'Available devices' section contains a table with columns: COM port, State, Instrument, Device, and Name or role. The 'For selected device' section contains tabs for 'Configure', 'Design segments', and 'Direct control', along with a 'Tools' section with an 'Initialize' button. Red arrows point to the splitter bars between the top bar and the first section, and between the two main sections, indicating where the form can be resized.

COM port	State	Instrument	Device	Name or role
X-COM	Unknown	Simulated	MFC	Virtual Demo
COM4	Unknown	2Wet	Pump	Prototype
COM5	Ready	2Mix	MFCB	Prototype
COM6	Unknown	2Mix	MFCB	Prototype

The form proportions can be resized by dragging on the splitter bars marked above with red arrows. This can be useful on a laptop with a small screen and low resolution.

## 5 Devices

The software searches for 2Mix and 2Wet devices from all available COM ports. The process is automatic once initiated by the user from the **Devices** menu. All found devices are listed on the **Available devices** list-view, with their relevant details.

The first listed device is a virtual device, for the purpose of trying out the software without the need of an actual physical instrument. Some functionality may not work properly for this demonstration device.

- COM port** Each device has its own COM port for communicating with the software.
- State** The device state is **unknown** at first, when the software does not know better. Once the user has configured the device the state changes to **ready**, meaning the device can now be operated. When device is performing a segment program, the state is **segment**, and **direct** when in direct control. Once these operations are stopped, the state changes to **idle**, which is the same as ready.
- Instrument** Either 2Mix or 2Wet.
- Device** 2Mix has two devices; mass flow controllers (MFCs). The MFCA with lower flow range, and the MFCB with larger flow range. 2Wet has single device the syringe pump.
- Name or role** The nickname or purpose of the device.

Many actions the software performs are done to the currently selected device, or devices. Use **ctrl** or **shift** and **mouse click** to select multiple devices.

## 6 Configuring a device

The screenshot shows the 'For selected device' configuration panel. It has tabs for 'Configure', 'Design segments', and 'Direct control'. The 'Configure' tab is active, showing fields for 'Device Type' (2Mix MFCB), 'Device Name' (Prototype), 'Device color in software' (32768), 'Fluid' (Ar), 'Flow unit' (min/min or sccm), 'Unit name' (min/min or sccm), 'Temperature, °C' (0), 'Pressure, bar' (14.696 psi), and 'Some ref. conditions' (0, 32, 1.01325, NIST, ISO 10780, formerly IUPAC (STP) until 1982). There are 'Apply configuration' and 'Initialize' buttons at the bottom.

The **configure** tab is used to define the parameters of the selected device.

**Device type** is read only property and shows instrument and device.

The **Device name** is nickname or role for the instrument.

**Color** of the device series on the graph and the color of the thread-communications led.

For MFCs, the **Fluid** is any of the hardcoded gases, any user-defined static gas mixture, or a dynamic mixture from another 2Mix device.

**Flow unit** is a combination of (flow) **unit name**, **reference temperature** and **reference pressure**. The drop down menu allows quick-selecting some typical reference conditions like mln/min or sccm. The unit g/min does not need reference conditions.

*In practice, volumetric flow units mean, that if the temperature and the pressure were as defined, the volume of the gas would be the said amount. The actual conditions are almost never the reference conditions, so the reported amount of flow and the actual amount of flow differ even as much as 10%. Furthermore the default, standard and normalized reference conditions have many conflicting definitions that vary between region and sector of industry.*

Therefore it is recommended always to stick to the same definition, practice, or use g/min which is independent of conditions.

By default 2Mix software and devices use 25°C and 1.01325 bar A as the reference conditions. This way, the actual flow and the reported flow are close to each other for most users.

For **pump** type device, the fluid list included distilled H2O and custom user defined liquids. The user may define the **syringe size** used in µL, and the **fluid temperature** in °C (which affects the fluid density).

Once all definitions are checked and confirmed, they are applied to the selected device when **Apply configuration** is clicked.

This tab also has the **Tools** section for special actions.

**Initialize** performs factory reset and applies the settings necessary for a device to work with 2Mix software. This is normally not necessary and should only be done when advised by the device support.

**Prime pump** performs several cycles of syringe fill/dispense to remove old fluid and or trapped air from the system.

**Change syringe** moves the plunger to the bottom position for syringe change (and locks the plunger in place until next software reset for safety)

The screenshot shows the 'Design segments' tab in the 2Mix software. On the left, a sidebar lists 'Name or role', 'Virtual Demo', 'Prototype', 'Prototype', and 'Prototype'. The main area is titled 'For selected device' and contains three sub-tabs: 'Configure', 'Design segments', and 'Direct control'. The 'Configure' sub-tab is active, showing fields for 'Selected device' (Prototype 2Mix MFCB), 'Maximum flow' (500 mln/min or sccm), 'Start time, m' (1 minute), 'Segment flow, %' (10 mln/min or sccm), 'Segment type' (Step), and 'Segment program termination type' (Keep last flow indefinitely). Below these are buttons for 'Start segment program(s)' and 'Stop segment program(s)'. To the right of the configuration fields are buttons for 'Add / Apply Segment' and 'Delete Segment'. A table with three columns (Time, m; Flow, %; Type) shows three segments: (0, 0, Step), (1, 100, Ramp), and (1, 0, Step). The third segment is highlighted in blue.

## 7 Design segments

A **segment program** is a list of instructions for a device to follow what time, what flow, and type of transition from one flow to another.

A **segment** is one instruction in a segment program. A segment has **start time** given in minutes, a **flow** given in % of device maximum flow, and **type** of transition.

This tab shows maximum flow for the device in user-specified units. The time in minutes is automatically shown as days, hours and minutes. The flow is automatically shown in user-specified flow units. The transition type **Step** is immediate while **Ramp** is linear transition from previous value to the current value.

It is possible to add and edit segments by clicking the **Add/Apply Segment** (a segment is edited if segment is selected, and added if not selected). **Delete segment** removes selected segment.

Segment termination type determines what happens after the last segment, the naming of the options is supposed to be self-explanatory:

- Keep last flow indefinitely
- Repeat segment program
- Stop flow (this device)
- Stop flow (all devices)

The **Start segment program(s)** button starts the segment programs for all selected devices.

The **Stop segment program(s)** button stops the segment programs for all selected devices.

7.1 Load and save segment programs

Right-clicking on the segment program list-view (not over existing lines) opens a pop-up menu with ‘load’ and ‘save’ options. These said operations allow for text file interaction for easy storing and reusing segment programs.

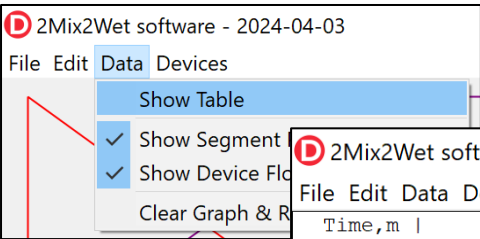
Should these files be edited manually, the format rules are follows:  
Each single line makes one segment of the segment program. A line is made of 3 mandatory items: **Time**, **Setpoint**, **Ramp type**, and an optional **Comment** item, each separated with empty space.

Time and Setpoint are decimal numbers with full stop as separator: 123.456 and the units are minutes and % accordingly. (Do note that for example 10% setpoint means different things on different devices as it is always defined from device maximum theoretical flow.)

Ramp type is either: Step or Ramp

Comment is one chunk of alphanumeric characters a to Z, 0 to 9, %, \*, @, / or \_ where the \_ character will be replaced with space when the program is loaded into the user interface.

7.2 Shared segments overview (Data table)



The data table (enabled from main menu) shows all the segment programs as a tabulated text, and is helpful to have visible while designing segment programs.

The table shows following columns.

- User defined time unit
- Human-readable time
- Device specific column with setpoint in %, and Type of segment. (Notes are omitted in this table), repeated for all present devices.

2Mix2Wet software - 2024-04-03											
File Edit Data Devices											
Time,m	Time	X-COM MFC		COM5 MFCB		COM6 MFCA					
		Setpoint	Type	Setpoint	Type	Setpoint	Type				
0.000				0	Step	100	Step				
1.000	1m	100	Ramp	100	Ramp	0	Ramp				
2.000	2m	100	Step	0	Step						
2.500	2m 30s	30	Ramp								
3.000	3m	50	Step								
3.500	3m 30s	30	Step								
4.000	4m	0	Ramp								
9.000	9m					11	Ramp				

Should device lack a segment at a time some other device has one, an empty column is added.



## 9 Direct control

The screenshot shows a software interface for device control. On the left, a sidebar lists 'Name or role' with options: 'Virtual Demo', 'Prototype', 'Prototype' (highlighted), and 'Prototype'. The main panel is titled 'For selected device' and has three tabs: 'Configure', 'Design segments', and 'Direct control' (selected). Under the 'Direct control' tab, there are two input fields: 'Maximum flow' with a value of '500' and units 'mln/min or sccm', and 'Setpoint, %' with a value of '15' and units '75 mln/min or sccm'. Below these fields are two buttons: 'Apply setpoint' and 'Stop'.

**Direct control** tab is the simplest way to control (configured) device or devices.

It allows applying a flow **setpoint** to one or more devices.

Applying a setpoint to a device will stop any segment program the device may be performing.

To stop the flow and the graph logging, click the **Stop**

button.

Each device will remember its direct control setpoint even when it is not “Applied” with the button, all it takes for a device to memorize the setpoint is to change the value on the field when a device is selected. When “Apply setpoint” is clicked, and when more than one device is selected, each device is started with its own memorized setpoint.

## 10 Pump setpoint

The screenshot shows a software interface for pump control. On the left, a sidebar lists 'Device' with options: 'MFC', 'Virtual Demo', and 'Pump' (highlighted). The main panel is titled 'For selected device' and has three tabs: 'Configure', 'Design segments', and 'Direct control' (selected). Under the 'Direct control' tab, there are two input fields: 'Maximum flow' with a value of '312.5' and units 'µl/min', and 'Setpoint, %' with a value of '0.000333'. Below the 'Setpoint, %' field, there is a line of text: 'Desired/Achievable || 0.001 041 / 0.001 041 || µl/min || Relative error:0.000 %'. Below these fields are two buttons: 'Apply setpoint' and 'Stop'.

The design segments and direct control in previous chapters had images with MFC selected. The functionality and process for Pump is the same, but some additional setpoint information is displayed.

The pump is able to dispense its contents very slowly, allowing setpoint down to 0.000 333 % of the (theoretical) maximum flow. Actual maximum flow is currently limited to ~30% of theoretical maximum flow in order to save syringe lifetime.

Beside the setpoint the resulting desired flow is displayed, as well as the actual achievable flow, and their relative difference.

Input fluid density is currently locked at 0.99819 which is the density of H<sub>2</sub>O at 20°C and the fluid input temperature will not change anything.

## 11 Pump ramp segments

In this manual text “pH<sub>2</sub>O” will signify any evaporated fluid content in the made mixture, as this is simpler to write than to say each time something like: “To achieve dynamically changing moisture, or any other evaporated fluid content”

In general ramp is a linear interpolation between start and finish setpoints. This works fine for MFCs, but for pump each setpoint change the pump receives new command, which starts with filling the syringe which takes about one second. By the time the device is handled again by the software (this happens many times per second), when performing a ramp-type segment, the setpoint has already changed, just a bit, and the new command always starts with refilling the syringe. So, a ramp-type segment with the pump would result just as endless loop of refilling the syringe. Instead the ramp-type segment for pump is accomplished by splitting the desired ramp into one minute long steps.

## 12 About dynamic fluid content

- In general experiments with changing pH<sub>2</sub>O should always advance from dry to moist or from low partial pressure to high. Doing the experiment the other way is slower and the effects on the experiment are gradual and harder to quantify.
- Pump segments are always steps, even when user asks for ramps, in which case the ramp is automatically converted to steps. These “ramp-steps” are always one minute long.
- Dynamic gas flow paired with static pump function produces smooth pH<sub>2</sub>O gradients when the one minute long steps are too coarse.

## 13 Mixture calculations

The screenshot shows the 'Mixture' tab in a software interface. On the left, under 'Recipe', there is a list of components: COM5 40.1 R, COM6 8.125 S, and COM7 0.000123 S. Below this is an 'Add segments' section with a 'Time, m' input field set to 10 and an 'Add' button. The main area on the right is labeled 'Mixture' and contains the text 'Mixture description comes here'.

Mixtures tab has the tools to quickly design segment programs based on mixture properties such as partial pressures of each component, total flow, absolute and relative humidity, mass and volumetric flow for each component and totals.

For the mixture designer to work, device(s) must be configured, i.e. they must have a fluid assigned to them to calculate the mixture with.

When suitable mixture design is achieved, it can be sent (**Add** button) to each participating device as a segment in their segment programs, added to the specified time, with the optional comment. The devices will then

achieve said mixture at said time (if their outputs are connected together).

In this early version the mixture design is text based. Each line represents one device source, and the calculations will automatically fetch the gas type and maximum flow for the device to be able to calculate the resulting mixture. The device is defined as capital COM suffixed with integer number matching the devices address. Space separates the device COM port from the desired flow given in % of device maximum flow, where decimals are separated with full stop. For convenience the segment type can be defined here, also separated with space; use R for Ramp and S for Step. The segment type can be omitted, and if so, the default segment type will be Step.

The screenshot shows the 'Mixture' tab with detailed calculations. The 'Recipe' section on the left lists: COM5 50, com4 1, and com6 30. The 'Mixture' section on the right displays the following data:

Mixture: 'Name'

Inputs:

Air	0.294	811	g/min
H2O	0.003	097	g/min
NF3	0.043	531	g/min

Components:

N2	0.226	146	g/min
O2	0.068	664	g/min
H2O	0.003	097	g/min
NF3	0.043	531	g/min

Partial pressures:

N2	733	640	ppm
O2	195	018	ppm
H2O	15	623	ppm
NF3	55	719	ppm

Volumetric flows, ml/min:

°C	BarA	N2	O2	H2O	NF3	Tot
0	1.01325	180.9	48.1	3.9	13.7	246.6
21	1.01325	194.9	51.8	4.1	14.8	265.6
25	1.01325	197.5	52.5	4.2	15.0	269.2
25	2.0265	98.7	26.2	2.1	7.5	134.6
150	1.01325	280.3	74.5	6.0	21.3	382.1

Mixture has fluid:

°C	BarA	Max ppm/100%RH	Current ppm	RH %
0	1.01325	6 033	15 623	258.954
21	1.01325	24 557	15 623	63.618
25	1.01325	31 285	15 623	49.937
25	2.0265	15 642	15 623	99.873
150	1.01325	4 689 580	15 623	0.333

Various flows from various devices, if combined, would make such mixture. Partial pressures, volumetric flows, and even relative humidity is calculated.