1 ToMix overview

ToMix is a gas flow control device, part of a modular product family with ToWet and the ToFlow software.

The mixer is controlled with computer software where user enters desired mixing profile of freely selectable dilutions, flows, ramps, steps, and delays.

The software can control multiple 2Mix units, and/or optional 2Wet units that allows adding (and evaporating) fluids.

The 2Wet and the software have their own manuals.

The default version of 2Mix is made with 2 gas lines, but custom versions with more gas lines are available and may be referred to in this manual.

Backside of 2Mix

1.1 Key concepts briefly

Pressurized gas lines are connected on the inputs A, B. The software controls the flow of each line independently, by regulating a valve, opening it for more flow, closing for less flow. These flows can be constant, ramps, or steps, according to the intended use.

Each gas line has their own output on the back of the device, and these gases can be led on as separate flows, or mixed together to form a mixture, with the included adapter(s).

With a separate 2Wet device an output gas or an output gas mixture from 2Mix device can be humidified, streamed, or injected/evaporated with any low viscosity fluid.

The software runs on a computer with Windows operating system, and talks to the device through an USB port. Multiple devices can be connected in a daisy chain or in parallel.

With the modularity user can build intricate flow regulation systems.

Both the 2Mix and the 2Wet operate at save 24 VDC and are powered by external CE marked power supplies.

The 2Mix is a straightforward device with high precision and high turndown ratio mass flow controllers.

Power switch is on when pointing up, towards the word “power”. When power is off, the mechanical spring will force all valves closed, preventing gas flow.

2 Background

When mixing gases, the possible range of mixing, the total flow of the made mixture, and the overall pressure of the system are all points on interest. Flow control devices have usable range of flow they can accurately control and measure. This range is often defined as full range and turndown ratio, and means the maximum achievable flow and its ratio to the lowest possible flow. A device with full scale flow of 200 (the unit is here irrelevant) and a turndown ratio of 50, would have an effective control range of 4-200.

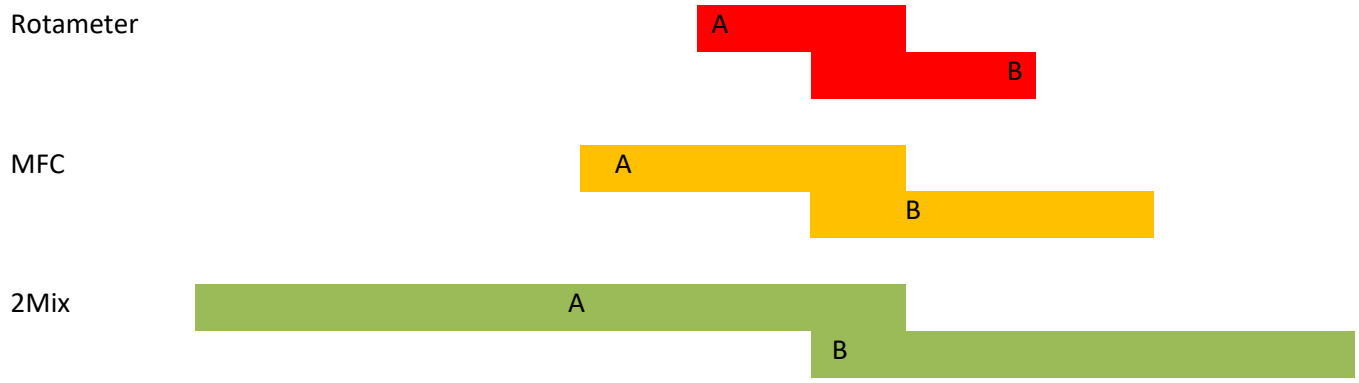
For a flow control device, the user can usually select the maximum flow range, whereas the turndown ratio is fixed and depends on the model, and ranges anything from 1:10 to 1:10 000.

Illustration covers three types of mixing devices. A pair of rotameters (red), pair of traditional mass flow controllers (yellow), and 2Mix (green).

Overall, rotameters have low accuracy and low turndown ratio, are operated manually with look-up table to convert the visual que to actual flow. Mass flow controllers operate automatically and have much improved accuracy, but do not match rotameters in simplicity and price. 2Mix uses state of the art flow control devices that are more accurate than conventional MFCs, and have two orders of magnitude higher turndown ratio.

To form a mixture, two of any said devices are used, we call them A and B. A control the flow of the gas to be diluted, and unit B controls the flow of the dilutant gas, and output from both is combined to form the mixture. The devices can have different flow ranges, lower flow for gas A, and higher flow for gas B, usually with some overlap in their ranges, to form mixtures near one to ratios.

Magnitude	-5	-4	-3	-2	-1	0	1	2	3	4
Flow	Pulsed	Tiny	Minute	Small	Low	Mid	Above	Large	High	Full



The overlap at mid flow is the region where the two flow control devices have same flow for both inputs and are able to produce mixtures close to 1:1 partial pressure ratio. For 2Mix it is possible to increase the overlapping mid-range if and when necessary.

The further apart the minimum for A, and the maximum for B, the larger dilution ratios the mixer can achieve.

A mixture of A:B is marked on the chart. The dilution ratio is defined by the distance of A to B, and is same for each type of mixer, whereas the total necessary flow to form the said mixture is lower the further left (on the chart) the A-B combinations are. This means forming the same mixture can be achieved by using less gases overall, saving money.

Overall, for mixers near 1:1 mixing it is good to increase the area of overlap, and for mixer aimed to produce large dynamic dilution ranges down to ppm levels, the overlap should be kept small. For ppb levels two units can be chained and product from one re-diluted with the next unit, the software supports input gases that are output gases from other 2Mix units.

3 Unpacking

The ‘Unpacking’ section in the manual is printed as separate sheet and included with the shipment.

3.1 The components

2Mix typically consists of the mixer, the power supply, the gas line connector and USB cable.

The software and the manuals are digital, with download link or email delivery.

3.2 The mixer

The mixer size may vary, depending on the amount of gas lines, but in all cases it is a compact desktop box,

Two gas lines: 11 x 20 x 22 cm
Four gas lines: 16 x 25 x 27 cm

On the front panel are inputs for gases A and B, and possibly other letters for additional gas lines.

The default version supports any non-corrosive gas, which are connected to the front panel 1/8” brass Swagelok bulkheads.

3.3 Inputs and outputs

Which gases to mix depends on the intended use, which varies over time. Each gas line remains independent inside the mixer, with inputs on the front panel, and outputs on the back panel, all labelled with letters A, B, C, D…

These gas in and -out match the devices (MFCA, MFCB, MFCC, MFCD…) in the software accordingly. (MFC for Mass Flow Controller)

It is up to the user to connect those outputs that are to be mixed. A small number of introductory and premade T-joints is/are included. Further gas line work is up to the user.

One of the typical uses is to combine outlets A & B, and connect that gas mixture as input to 2Wet device.

3.3.1 Swagelok connections

Do not use tools to tighten existing Swagelok connection. Only as tight as done with fingers is enough.

For those not familiar making new Swagelok connections, refer to Swagelok manuals or website. For those who are familiar, but do not remember the amounts to turn: With 1/8” gas line 3/4 turn. With 1/4” gas line 5/4 turns.

3.4 Power supply

CE marked power supply is included in the system, and is suitable for 110-230 VAC and both 50 and 60 Hz. The mains cable included has Hybrid CEE 7/7 plug, and can be changed to match the local sockets. The connector on the power supply is called C14.

4 Usage consideration

4.1 Input gas quality

Only use with (bottle) dry gases. A humid gas has considerably different properties and can not be controlled accurately, and in worst cases will cause condensation in the gas line, leading to a host of problems.

The input gas can also be a gas mix, most commonly, air, but also custom mixtures. Static, and dynamic custom input mixtures as inputs is an advanced subject (currently) outside the scope of this manual.

4.2 Safety

4.2.1 Emergency shutoff

When power is off (switch pointing down), the mechanical spring inside the flow controllers will force all valves closed, preventing gas flow.

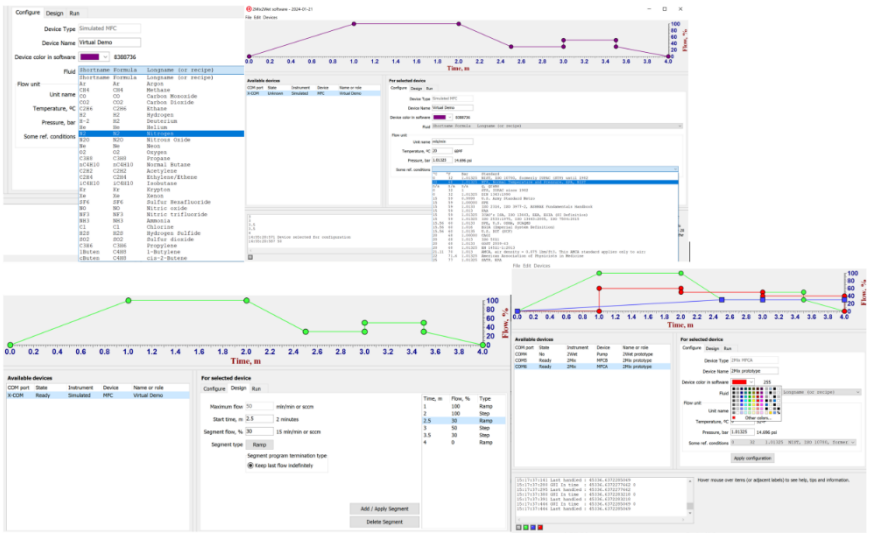
4.2.2 Leakage

A mass flow controller is not inherently safe as a long-term close-off valve. Remove pressurized gas from the device when not in use.

The system is pressure tested during manufacturing QC with 4 bars of Air. Small leakages (of gases like H2 or He), particularly with high operating pressures, may exist. When used with dangerous gases, all appropriate alarms and ventilations according to local laws must be in place. It is prudent to assume that something will break (for example a sealing gasket), something will leak (Swagelok connection), some error will be made (gas output not connected). So plan and prepare safety routines accordingly.

5 2Flow Software

2Mix is controlled by software running on a Windows computer (computer not included). The software allows user to design and control flow patterns for single or multiple inputs as one output ‘mixture’, and will show the resulting flow in various units, partial pressures, RH%, etc. relevant information.



The software allows user to select the input gases or gas mixtures used in the mixer. The inputs can be elemental gases, default mixtures, user defined mixtures, or live mixtures; a dynamic mixture output from one 2Mix as input to another 2Mix.

The user can design the desired mixtures as constant flow or as a segment program with custom amount and length steps or ramps. One segment program can control multiple 2Mix units, or each unit can have its own segment program or software instance running. When a segment program is finished it can stop the flow for one 2Mix, for all 2Mix units, maintain last mixture and flow, or start over from beginning.

Segment programs can be saved and loaded for further use, and all performed flows are automatically saved to disk with dates and times for reference.

The 2Flow has separate manual.

6 Specifications and order sheet

The default specifications can be altered to match user needs, please fill in the highlighted points on this document or otherwise convey the information.

6.1 Pressure range

Maximum pressure:	11 bar a	bar a=atmospheric	bar g=reading on pressure gauge
Pressure option:	22 bar a	> 11 bar a pressure tradeoff is lower turndown ratio and reduced accuracy	
Minimum pressure:	0.7 bar a	(or absolute)	(above atmospheric)

The optimal situation is where the input pressure (gas supply) is roughly one bar more than the output pressure (experiment pressure). This one bar difference ensure there is enough force to reach the maximum specified gas flow when the valves are fully open, but not so much force that the PID controlled valve would have difficulties finetuning the orifice size for small flows and small flow changes.

6.2 Flow ranges and dilutions

A device for each input line has predetermined flow range in which the device is able to accurately control the flow. This range is indicated as the maximum flow, where the minimum possible flow is omitted but is a fraction of the maximum flow.

Flow range forth both input lines can be selected to best match the desired use case. This will affect the possible mixing ratio and total flow of the mixer. Any flow range is possible, from microliters to hundreds of liters. The defaults are for N2 and mixing situations where both gases have identical mass and viscosity. SCCM Standardized cubic centimeter per minute = milliliter per minute ml/m

	Defaults
Max flow input A	50 SCCM
Max flow input B	500 SCCM
Flow range for 1:1 mixing (4 magnitudes)	0.1 - 100 SCCM
Max dilution (pulse A + max B)	1:1 000 000

It is possible to increase or reduce the overlap, the mid-range, and accordingly (inversed) reduce or increase the maximum dilution range. In usually not necessary to aim for larger dilutions than 1:100 000, as source gases and leakages ensure ppm levels presence of undesired elements in the mixture in any case.

6.3 Options

- Corrosive gases
- High pressure
- Additional gas lines

Custom 2Mix with 4 gas lines

All pure non-corrosive gases

Acetylene (C2H2), Air (clean, dry), Argon (Ar), Isobutane (i-C4H10), Normal Butane (n-C4H10), Carbon dioxide (CO2), Carbon monoxide (CO), Deuterium (D2), Ethane (C2H6), Ethylene (Ethene) (C2H4), Helium (He), Hydrogen (H2), Krypton (Kr), Methane (CH4), Neon (Ne), Nitrogen (N2), Nitrous Oxide (N2O), Oxygen (O2), Propane (C3H8), Sulfur Hexafluoride (SF6) 1, Xenon (Xe)

Bioreactor Gas Mixes

5% - 95% CH4/CO2 in 5% increments

Breathing Gases

Metabolic Exhalant, EAN-32, EAN-36, EAN-40, EA-40, EA-60, EA-80, Heliox-20, Heliox-21, Heliox-30, Heliox-40, Heliox-50, Heliox-60, Heliox-80, Heliox-99

Chromatography Gas Mixes

P-5, P-10

Fuel Gas Mixes

1% - 99% H2/Ar in 1% increments
1% - 99% H2/N2 in 1% increments
Coal Gas 50% H2, 35% CH4, 10% CO, 5% C2H4
Endothermic Gas 75% H2, 25% N2
HHO 66.67% H2, 33.33% O2
LPG HD-5 96.1% C3H8, 1.5% C2H6, 0.4% C3H6, 1.9% n-C4H10 LPG HD-10 85% C3H8, 10% C3H6, 5% n-C4H10

Laser Gas Mixes

4.5% CO2, 13.5% N2, 82% He
6.0% CO2, 14% N2, 80% He
7.0% CO2, 14% N2, 79% He
9.0% CO2, 15% N2, 76% He
9.4% CO2, 19.25% N2, 71.35% He
9.0% Ne, 91% He

Natural Gases

93.0% CH4, 3.0% C2H6, 1.0% C3H8, 2.0% N2, 1.0% CO2 95.0% CH4, 3.0% C2H6, 1.0% N2, 1.0% CO2
95.2% CH4, 2.5% C2H6, 0.2% C3H8, 0.1% C4H10, 1.3% N2, 0.7% CO2

Oxygen Concentrator Gas Mixes

89% O2, 7.0% N2, 4.0% Ar93% O2, 3.0% N2, 4.0% Ar95% O2, 1.0% N2, 4.0% Ar

Synthesis Gases

40% H2, 29% CO, 20% CO2, 11% CH4
64% H2, 28% CO, 1.0% CO2, 7.0 CH4
70% H2, 4.0% CO, 25% CO2, 1.0% CH4
83% H2, 14% CO, 3.0% CH4

Stack/Flue Gas Mixes

2.5% O2, 10.8% CO2, 85.7% N2, 1.0% Ar
2.9% O2, 14% CO2, 82.1% N2, 1.0% Ar
3.7% O2, 15% CO2, 80.3% N2, 1.0% Ar
7.0% O2, 12% CO2, 80% N2, 1.0% Ar
10% O2, 9.5% CO2, 79.5% N2, 1.0% Ar
13% O2, 7.0% CO2, 79% N2, 1.0% Ar

Welding Gases

C-2, C-8, C-10, C-15, C-20, C-25, C-50, C-75, He-25, He-50, He-75, He-90, A 1025, Stargon CS

Pure Corrosive Gases

Ammonia (NH3)
Butylene (1-Buten)
Cis-Butene (c-Buten)
Isobutene (i-Buten)
Trans-Butene (t-Buten)
Carbonyl Sulfide (COS)
Chlorine (Cl2)
Dimethylether (DME)
Hydrogen Sulfide (H2S)
Nitrogen Trifluoride (NF3)
Nitric Oxide (NO)
Propylene (C3H6)
Silane (SiH4)
Sulfur Dioxide (SO2)

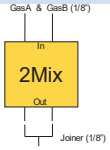
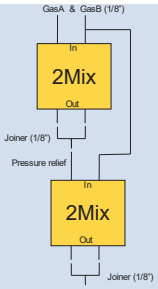
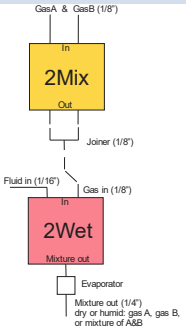
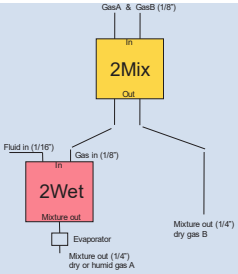
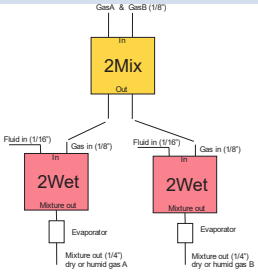
Refrigerants

R-11, R-14, R-22, R-23, R-32, R-115, R-116, R-124, R-125, R-134a, R-142b, R-143a, R-152a, R-318, R-404A, R-407C, R-410A, R-507A

7 Summary

2Mix	2Wet	2Mix software
Measure or Control flows of two gases separately, or mix them together Defaults: - Gas A: 0.005 – 50 mln/min - Gas B: 0.05 – 500 mln/min Flow range for both MFCs adjustable at time of order up to 20 ln/min - Any non-corrosive gas or gas mixture - Max pressure 10 bar A - Size: 11 x 20 x 22 cm, 3kg Options (surcharge): - Corrosive gases - High flows, 5000 l/min - High pressure, 20 bar - Ultra high pressure, 250 bar - Custom builds with more MFCs	Add low viscosity fluid (like distilled H2O) to passing gas stream and evaporate the fluid. Added amount is adjustable and software will show RH% and partial pressure of fluid components. Defaults: - 0 to 100% absolute humidity - 0 to 100% relative humidity RH - Evaporator 150°C - Heating power 250W - 0 to 3g H_2O/min @ ATM - Size: 16 x 22 x 27 cm, 5kg - Evaporator 1.2 m, bend radius 30 cm - Max pressure: 5 Bar A Options (surcharge): - Heating power up to 5 kW - Higher fluid throughput - Custom static evaporator shapes - Larger syringe sizes up to 60 g H_2O / min - Higher temperature evaporator	Control any amount of 2Mix and 2Wet devices from single MFC to dozens of MFCs, 2Mix and 2Wet devices. Defaults: - Manually specify device flow - Segment program with steps and ramps for any and all connected devices - Partial pressure calculations - Plot flows and mixtures on screen - Save flows and mixtures on file Options (surcharge): - High temperature equilibrium calculations - Dynamic input gas for 2Mix (allows mixture re-dilution by using 2x 2Mix in chain) - User defined custom input fluids - PLC integration (report flows via RS485/Modbus/ASCII, cut power relay)

At the simplest, the 2Mix software is an easy way to control individual mass flow controller or many mass flow controllers with simple dial, and plot the flow, and record the flow as function of time to a file. The software allows user to view flows (per minute) in their preferred unit; % of full flow, grams, or standard volumetric units mln, mls, sccm, or custom volumetric units with user defined reference conditions (temperature and pressure). For the reference conditions the software uses °Celsius and Bar A, but accommodates also for users of °Fahrenheit and PSI.

Name	Schematics	Use case	Notes
-Flow control **-Flow measurement** **-Fuel cell without humidification**		Control flow of each Gas A and Gas B individually. A & B can always be pure species or premade mixtures.	Constant flow, ramps, steps
A+B mixture		Create dynamic large range mixtures of Gas A and Gas B	Software reports partial pressures of all components at any given time
Re-dilution (A+B) + B		Take some of A+B mixture and re-dilute with large amounts of gas B for ppb levels of A in B	
Humidification pH2O of gas or gas mixture **Evaporate custom fluids in gas or gas mixture**		From bottle dry gas A, gas B, mixture of A+B to pure steam or any combination	
One sided humidification		Gas A and Gas B can be premade mixtures from bottle or from another mixer.	
Double sided humidification			
Full control of two mixtures