BLENDER X

USER MANUAL

version 2.1

Disclaimer

Please note that you need gas blender certification in order to use BlenderX. Reading this manual does not make you a certified gas blender but is required reading for any gas blender for safe operation of blenderX.

This equipment is meant for professionals with experience on scuba diving, gas blending and mixing. Misuse or improper use of BlenderX or any gas blending equipment may lead to personal injuries including death and property losses or damages. Abyss Core Inc. is not responsible or liable for any damages or injuries under any circumstances. By purchasing this equipment, you agree to these terms

In layman's terms: YOU need to know what YOU are doing!

Please contact us via email for any questions regarding training for personnel and proper use of BlenderX at support@abysscore.com

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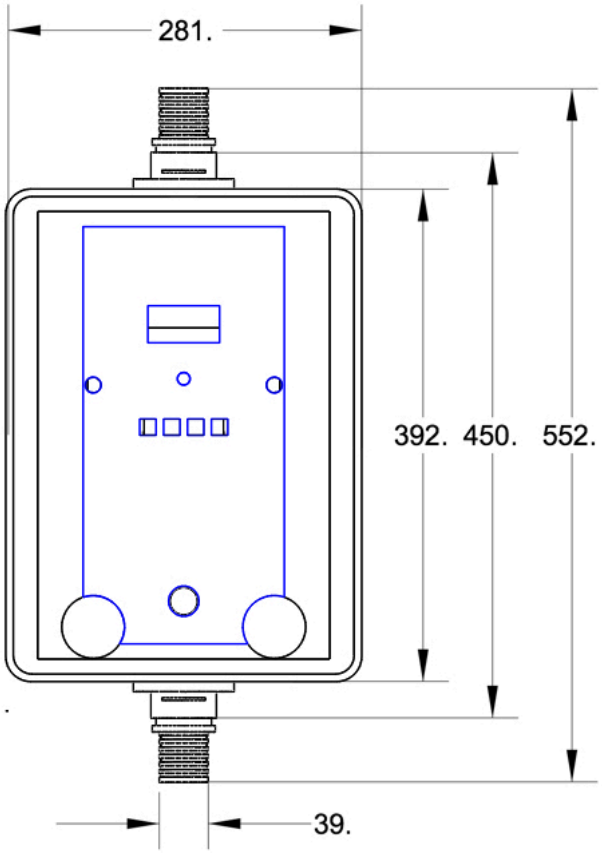
Introduction

Congratulations for acquiring blenderX for your gas mixing needs. BlenderX is a continuous flow blending panel which operates in conjunction with a breathing air compressor for producing Nitrox or Trimix gas mixes.

This is the most robust way of mixing gas mixes with less than 40% of Oxygen content.

Specification

Operating voltag	12 VDC
Max gas pressure	5 bar
Oxygen sensor type	R-22D
Hose connectors	22-32 mm
Width	281 mm
Length	500 mm
Thickness	195 mm
Weight	9 kg
Min operating temperature	0°C
Max operating temperature	40°C
Min storage temperature	-40°C



BlenderX V2 is shipped with following items:

- ✓ complete assembled blending panel
- ✓ 12VDC 3A power adapter
- ✓ this manual in printed format

Requirements

In addition to blenderX you need least following to start mixing:

- A well maintained and a good quality breathing air compressor
- Supply bottles of breathing grade Oxygen and Helium (in the case of Trimix mixing)
- Pressure regulators for supply gasses with pressure range of 1 to 6 bars (15 to 90 psi)
- 1/4” male NPT adapters for what ever gas delivery installation is used.
- Hoses and adapters for connecting compressor inlet to the blenderX outlet (39mm pipe)

As you can see, you can start mixing with minimal additional equipment. Oxygen and Helium supply bottles and valves differ from country to country so you need to consult your local gas supplier for finding right type of regulators and connectors. AbyssCore can supply you with adapters for blenderX input and output pipes for different sizes of hoses.

Compressor Requirements
Mixing Trimix with normal breathing gas compressor may present problems with high helium contents. As helium is such a small molecule gas it can leak from places which oxygen or nitrogen cant. Examples of such places are loose or worn out piston rings and one way valves

This sets high standards for compressors that are to be used with high fractions of helium. problems that might occur from these conditions are overheating of the compressor as compression ratio increases due to flow back of the helium. The problem is most pronounced in last stage of the compressor.

Should you suspect such a problem, you should refrain from mixing such high helium content mix. It helps to diagnose the problem if you have interstage pressure gauges fitted to the compressor.

Over heating of the compressor may lead to other hazards if the mix also have elevated oxygen content. Experience has shown that it is not a problem to run mixed of up to 40% of helium with normal breathing air compressor that has been properly maintained.

In the case of high helium content mixes it is also possible to combine partial pressure mixing with the blenderX.

Panel Parts

This section describes and explains different elements of the blenderX these explanations are referred in the rest of the document.

	Parts description
1	Input air pipe 38mm
2	Output pipe to compressor 38mm
3	Power socket 12V CNlinko
4	Oxygen Needle valve
5	Helium Needle valve
6	Power switch
7	Calibration button
8	Directional command buttons

	Parts description
9	Oxygen input 1/4” Female NPT
10	Helium input 1/4” Female NPT
11	Sensor 2 port
12	Sensor 1 port

	Parts description
13	Sensor 2 connector
14	Sensor 1 connector
15	Ethernet port
16	Compressor relay connection

Display Screens

Different display screens and areas are explained here:

	Item description
a	Sensor 1 FO2 reading
b	Sensor 2 FO2 reading
c	Operating mode / error
d	Current gas mix (Oxygen/Helium %)
e	Target gas mix (Oxygen Helium %)
f	Guide arrrow

	Item description
h	Sensor 1 mV output
i	Sensor 1 calibrated value
l	Time elapsed
k	Sensor 2 calibrated value
l	Sensor 2 mV output

Quick Start

First of course read this whole manual. After that here is the quick start guide for start blending:

1. Connect blenderX between intake air filter and compressor intake. Air filter hose is connected to input pipe (1) and compressor intake hose to output pipe (2).
2. Provide 12V DC to the blenderX by included power adapter or by other means, ie. battery. Power adapter is connected to power socket (3)
3. Connect supply gasses to blenderX. Oxygen goes into **left hand side** input (9) and helium into **right hand side** input (10). **!DO NOT OPEN SUPPLY GAS TANKS YET!**
4. Make sure needle valves (4) and (5) are closed by turning then **clockwise** direction
5. Turn on power to the blenderX by turning the key in power switch or pulling it up depending on the power switch type fitted into the panel(6). It takes about **one minute** for panel to boot up
6. Turn on the compressor and bleed gas either from tank filling valve or from condensate drain after 3rd stage
7. After blenderX is ready calibrate sensors by pressing calibrate button (7)
8. Once calibration is finished both sensor readings (a)(b) should show 20.9 and mode (c) should read “Ready”. Mix (d) should read 21/00
9. Select desired mix by using arrow keys (8) until target mix (d) reads correct values. This will change mode (d) to either Nitrox, Trimix, Booster or Ready and open appropriate solenoid valves
10. By using needle valves adjust gas flow so that mix (d) is the same as target mix (e)
11. Close filling valve or condensate drain that was opened in step 6. and open tank valve once pressure has build up enough for filling
12. Observe the mix and adjust gas flows if necessary
13. When cylinder has been filled and there are no more tanks to fill, **close supply gas valves** and **let compressor run** and bleed gas either from filling valve or from 3rd stage condensate drain. Let needle valves (4) and (5) also remain open
14. When mix (c) reads 21/00 you can close the compressor. This endures that there is no gas left in the supply lines that could cause trouble on the next time of usage.

Operating Principle

blenderX is a continuous flow blending panel. This means that component gasses are added into the compressors input airflow and by that means the desired gas mix is achieved. This method of blending well know and most widely used especially with Nitrox. Effectively Nitrox membrane systems are similar by removing nitrogen from compressor input air and therefore feeding compressor with oxygen enriched air.

Same limitation also applies to both blending methods which is industry standard maximum oxygen percentage of 40% for non-oxygen clean equipment. Nitrox membrane is inherently safer as the 40% limit cannot be accidentally exceeded. With continuous flow mixing compressor can be injected with too much oxygen as a result of operating error or equipment malfunction. blenderX is designed to remove most of the risk factors by using variety of sensor technologies to detect any abnormal operating condition. blenderX does not remove all the risks as it is also technical equipment and it can fail in wrong conditions.

Following Formula described the method used for calculating the helium percentage. Since oxygen is injected after helium in the mixing stick, formula is slightly more complex than if helium was injected last. Reason being that injected oxygen affect the amount of oxygen which comes with input air.

$$FO_{2_{s1}} = FO_{2_{air}} \cdot \frac{1 - FO_{2_{s2}} - FHe}{1 - FHe \cdot FO_{2_{air}} - FO_{2_{s2}}}$$

Where:

- FO_{2s1} is Oxygen fraction at the first oxygen sensor which is placed after helium is added,
- FO_{2s2} is Oxygen fraction at the second and last oxygen sensor which just before gas is directed to compressor,
- FO_{2air} is oxygen fraction of air, 0.209 most commonly,
- FHe is fraction of helium in the final mix

Preparation procedures

In preparation to filling you should have following items in hand and assembled:

- Gas supply tanks with pressure regulator attached and adjusted for absolutely no more than 6 bar pressure. Preferable operating pressure is 2-3 bars. This way needle valves are easier to operate.
- Breathing air compressor with good working condition. As with any Nitrox filling, it is preferable to use synthetic compressor oil with as good high temperature characteristics as possible
- Particulate filter to be attached into input pipe of the blenderX. It is mandatory to prevent dust and other small particles from enter into blenderX. Particle collisions and heat that is formed due to that are one potential source for flashing. Even though there never should be more than 40% rich nitrox in the stick, in problem situation this limit may be momentarily exceeded. Therefore great care should be taken with operating environment and finishing procedures.
- 12V DC electricity supplied to the panel via included power adapter or by other DC power source.
- **Needle valves should be closed.** It is important to follow this precaution as solenoid valves may be open momentarily when panel is opened.
- **Open supply gas tank valves only after panel has booted and is in operational mode.**

Finishing procedures

When finishing the gas mixing, it is necessary to drain gasses from the miming system. This procedure should be followed especially when panel is left connected to the compressor or is fixed mounted. The best procedure for finishing the mixing session is as follows:

1. Let the compressor run and bleed gas from 3rd stage purge valve
2. Close supply tank valves
3. Let needle valves be open and panel in Trimix mode
4. When both sensor readings are close to 21% close the compressor
5. Panel is now ready to be shutdown

This procedure ensures that no oxygen is left to supply gas lines. If there is a malfunction of solenoid valve and needle valve left open, oxygen can build up to the mixing stick. This would lead to situation where compressor would suck close to 100% oxygen when started afterwards.

It is also possible to just close the compressor and cut power from the panel, which will close solenoid valves. If panel is to be removed for transportation, this procedure does not pose any additional hazard.

Calibration

BlenderX can calibrate its oxygen sensors automatically when user presses calibration button. Calibration sequence closes all solenoid valves, but still it would be best to keep needle valve closed and gas supply valves closed.

Calibration should be done while compressor is running. This way you can ensure that sensors are feed with air. Compressors also induce some vacuum while running in inlet air hoses which can result in incorrect readings if calibration was done in other state. Oxygen sensors that are used do not sense oxygen percentage as such but oxygen partial pressure. Therefore changes in ambient pressure affect sensor readings. blenderX has a facilities to compensate for that change in conditions but still it is best do calibration in same conditions as actual mixing.

It should be noted that it is possible to get wrong calibration result if system is calibrated while enriched air is remaining in the mixing stick. Such condition can result in hazardous situation where too high oxygen percentage is injected into the compressor.

Nitrox mixing

Mixing nitrox is straight forward with blenderX. Make sure that all necessary parts are connected and ready to be used. That includes input air filter, supply gas of 100% or close oxygen, pressure regulator for oxygen with correct type of connector for the blenderX and of course the compressor.

Procedure for mixing Nitrox is as follows:

1. Follow the steps in the chapter “Preparation Procedures”
2. Calibrate the the panel using procedures described in the chapter “Calibration”
3. Set target mixture (e) using arrow keys (8). You only need to set the Oxygen part to desired reading.
4. Mode are (c) should read “Nitrox” and when it changes to Nitrox you should hear a click sound from the solenoid valve.
5. Adjust Oxygen percentage with needle valve (4). Start by opening the valve carefully and seeing how the sensor 2 reading (b) and oxygen part of the current mix reading (d)
6. When the current mix is within 1% of the target, wait for a while and bleed the compressor from excess gas.
7. Then just fill the tank as per usual
8. Keep an eye on the oxygen reading as flow rate of the oxygen can change due to supply gas line cooling. It is also possible that compressor performance can change towards the end of the filling.

Panel should protect from injecting too high oxygen concentration gas into the compressor. Solenoid valve will close when oxygen percentage goes over 40.0%. This can be cumbersome when mixing 40% mix, but is necessary to protect the compressor. Panel will give error 0x802 when oxygen goes over this 40% limit. Solenoid will stay closed for some time after the oxygen percentage has drops under 40%. If this happens frequently, it can throw off the final mix. Therefore it is especially important watch over the mixing when blending these high FO2 mixes.

Trimix mixing

Mixing Trimix is essentially the same as mixing as Nitrox but involves inert gas (helium) addition to the mixing stick before oxygen. Mixing Trimix is little more tricker than Nitrox as the gas flow of each gas affects to the other.

Procedure for mixing Trimix is as follows:

1. Follow the steps in the chapter “Preparation Procedures”
2. Calibrate the the panel using procedures described in the chapter “Calibration”
3. Set target mixture (e) using arrow keys (8). You only need to set both the oxygen and helium parts to desired reading.
4. Mode are (c) should read “Trimix” and when it changes to Trimix you should hear a click sound from the solenoid valves.
5. Adjust Oxygen percentage with needle valve (4). Start by opening the valve carefully and seeing how the sensor 2 reading (b) and oxygen part of the current mix reading (d)
6. Let the oxygen percentage rise roughly 2-3% higher than the target.
7. Adjust helium flow so that helium part of the current mix (d) to match the target mix. This will affect oxygen portion as there is less air entering to the mixing stick and thus less oxygen.
8. Iterate by adjusting oxygen to match the target mix and compensate helium flow accordingly
9. Once the current mix (d) is the same as target mix (e). Bleed gas from the compressor in order to have correct mix go into tanks
10. Then just fill the tank as per usual
11. Keep an eye on the oxygen reading as flow rate of the oxygen can change due to supply gas line cooling. It is also possible that compressor performance can change towards the end of the filling.

Principle of how helium portion is calculated is explained in “Operation Principle” -chapter. You can calculate the value of the first oxygen sensor (a) with the given formulas if you have any doubt about the operation of the panel.

Web Interface

BlenderX Version 2 comes with Wi-Fi and Ethernet connection. This enables you to see mixing processes and panel state remotely. If you have Wi-Fi network available you can set the BlenderX connect to it when it is started. To use the web interface following requirements have to me met:

- Network available that has DHCP service running

Web interface can be accessed with browser that is connected to same network as the BlenderX. You just need to know the IP address of the BlenderX.

To find out the IP address, you need to scan your network after BlenderX has been connected to the network. This is easiest done by connecting it via Ethernet connector. After BlenderX has booted and connected to the network, you should use network scanner or your gateway device to find out new devices connected to the network.

Maintenance

BlenderX is low maintenance equipment. Oxygen sensors are fuel cell type and there fore have a limited lifetime. Oxygen sensors should be replaced annually or when they fail to calibrate. Maximum ppO2 that sensors are required to display correctly is 0.4 bar, therefore the ageing process can be slow.

Oxygen sensors that are used are the type that is most commonly used in rebreathers (R-22D). They use 3-pin Molex connector to provide voltage in range of 8-25mV while exposed to air in normal atmospheric pressure. If you use different type of oxygen sensor in your rebreather it is possible to modify the sensor connector as long as the voltage provided by the sensor is on the same range. While you should always use perfectly working sensors in gas mixing, in a pinch you can also use dated rebreather sensors in panel. As mentioned partial pressures that sensors should display correctly is relatively low compared to rebreather where it must be able to correctly measure as high as 1.6 bar partial pressure. Therefore sensor that is not able to correctly show partial pressures over 1 bar still is able to measure pressures up to 0.4 bar.

Other than O2 sensors, there are no practically wearing parts in the system except solenoid and needle valves. It should be noted that oxygen part of the input gas line needs to be oxygen cleaned. This can be done by the user or panel can be sent to factory for service. Cleaning of the valves is not necessary if only pure gasses are used for filling. If for example gas that is boosted with oil lubricated compressor is used as a supply gas, then entrained oil can accumulate into valves and periodic cleaning is necessary.

Other than oxygen supply line is not subject to higher than 40% oxygen concentration so oxygen cleaning is not strictly necessary. It is how ever very strongly advised to use oxygen compatible lubricants and materials in all replacement parts.

Trouble shooting

In the case of some problem, blenderX tries to minimize serious consequences by cutting out gas supplies. In such case error code is shown in the **mode area**. Summary of error codes are presented in the following table

Code	Name	Description
0x800	General Failure	Failure due to causes which can not be identified
0x801	Sensor Failure	Sensors fail
0x802	High FO_2	Too much oxygen is injected into mixing stick
0x803	Gas Bypass	Air leaks into the mixing piping. Cause can be structural problem or O-ring failure
0x804	Memory Error	Internal memory is corrupted
0x805	Sensor1 Failure	Sensor 1 gets disconnected
0x806	Sensor2 Failure	Sensor 2 gets disconnected
0x807	Compressor Failure	Compressor RPM drops bellow set limit
0x808	Calibration Error	Sensors give out too high reading during calibration. Cause is most likely residue oxygen in input air or sensor failure