

Current limited oxygen cells

An oxygen cell generates current.

By passing this current through a resistor, then measuring the potential difference across that resistor a millivolt output is obtained and it's this mV output that the rebreather electronics measure and in turn display as an oxygen pressure by simply multiplying the cell output by a stored calibration factor for that cell.

The higher the oxygen pressure, the higher the current and subsequently the higher the mV output will be. However, there is a limit as to how much current the cell can physically produce and this is called the "current limit".

Current limiting is seen in all oxygen cells regardless of age (often around 4.5 bar when new) but as the cell ages the lead anode is consumed and the cell's ability to produce current is reduced.

It is worth remembering that the storage conditions affect the rate of decay: the higher the oxygen pressure the cell is stored in the faster the lead anode is reduced. If you store a cell in pure oxygen for instance, it will last just a few months. GUE recommends cell storage in air.

Current limiting only becomes a problem when the maximum output of a cell is below the required set point and then with the voting logic on the JJ rebreathers it only becomes a problem when a 2nd cell is also current limited below or just above the set point.

The JJ rebreathers use the average of the closest two cells to determine whether to add oxygen or not. For example, if you have one cell on 1.30 and one cell on 1.26 and the third cell on 1.68, the electronics assume that the PO₂ is half way between the closest two, in this case 1.28 and the solenoid would open. However, if both the lower output cells are current limited then the true PO₂ might be 1.68 and climbing. In this instance because one cell is more than 0.2 bar from the average of the closest two - the cell warning will be active.

The easiest way to avoid current limiting being a problem is to throw the cells away when they are 12 months old. If you use the cells past 12 months then you HAVE to check for current limiting. The problem is you have to check often during the dive as the drop off is sudden. This is easy to do - you simply have to add a bit more oxygen and prove to yourself that the display will go well above the set point, but doing it once on a dive isn't enough, you need to check it every 5 -7 minutes or whenever you think the solenoid activity is too frequent.

Solenoid Activity

Knowing what to expect from the solenoid at different stages of the dive is an essential part of a rebreather diver's armory.

During the ascent you expect the solenoid to operate a lot. The oxygen pressure naturally drops as you ascend and the machine tries to maintain set point.

However, at all other times the solenoid activity is MUCH less. On the descent for instance, you wouldn't expect it to operate at all and on the bottom you expect it to operate intermittently - just replacing the oxygen you metabolize.

The JJ rebreather electronics have a slow or fast option adjusting delay in seconds before it decides whether to open the solenoid or not and the duration of the opening time varies with how far the oxygen pressure is below the set point. If the oxygen pressure drops low enough, the solenoid will open continuously.

On the bottom with minimal depth changes the machine is only adding oxygen to replace the oxygen that you metabolize so you're not expecting long injections and you're not expecting injections every 3 seconds, so if the solenoid starts adding gas so frequently look at the handset and find out why.

If the oxygen addition is sufficient you'll find your buoyancy increases - again abnormal increases in buoyancy need further investigation.

Being aware of how your rebreather normally operates in all phases of the dive is an essential tool in knowing when the rebreather is operating abnormally.

What do I do if I suspect Current Limiting?

The danger is Hyperoxia - too much oxygen, so your actions do depend on how long you have been exposed to high levels of oxygen.

If you dive with old oxygen cells you **HAVE** to be checking for current limiting throughout the dive and be checking at least every 5 minutes. This is the reason why **You should never dive with cells older than 12 months!**

A routine check would include:

- Add oxygen - are the cells able to go higher than the set point?
- If they are not able to display higher, do a good... long... diluent flush

- Change to the low set point, 0.7

• Remember: **DO NOT CONTINUALLY SUPPRESS CELL WARNINGS**. A cell warning needs further evaluation - which includes physical actions to check which cell is giving you the correct value. **CELL WARNINGS MUST NOT BE IGNORED** and **BAILOUT** to open circuit initiated.

There is no substitute for regular monitoring of your handset display, **DO NOT RELY ON HUD ONLY**.