

## Important Manufacturer Warning

March 2nd, 2013.

It was in the early 2000s when we last heard of divers experiencing problems when using old oxygen cells, luckily without fatalities. Unfortunately there have been two recent fatalities where out of date oxygen cells were used.

At 3 years old most Teledyne cells used in rebreathers will not rise above 1.3 bar, no matter how much oxygen pressure you expose them to, at 2.5 years old some Teledyne cells will not rise above 1.3, at 2 years old we heard of the odd case. At 18 months we didn't hear of any incident of current limiting – when stored in air between dives.

This is where APD's 18 month recommendation for replacing cells comes from.

The Teledyne cell manufacture date is printed on the label in a simple code: D9 is April 2009.

Teledyne stopped making cells for rebreathers in 2010, so even if you have a H0 cell, August 2010, the last cells produced for diving were made more than 2 ½ years ago.

**Teledyne R22 and R17 cells MUST NO LONGER be used in rebreathers.**

### Current limited 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. 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. AP recommends storage in air.

**Current limiting only becomes a problem when the maximum output of a cell is below the required setpoint** and then with the voting logic on the APD rebreathers it only becomes a problem when a 2<sup>nd</sup> cell is also current limited below or just above the setpoint. The APD 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 PO<sub>2</sub> 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 PO<sub>2</sub> 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 18 months old. **If you use the cells past 18 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 setpoint 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 armoury.

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

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 metabolise.

The APD Vision electronics have a 3 seconds delay before it decides whether to open the solenoid or not, on the Classic electronics it is 6 secs, and the duration of the opening time varies with how far the oxygen pressure is below the setpoint. 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 metabolise so you're not expecting long injections and you're not expecting injections every 3 secs, 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.

A routine check would include:

- Add oxygen – are the cells able to go higher?
- If they are not able to display higher, do a good... long... diluent flush
- Change to the low setpoint , by pressing and holding the centre button and see if it runs okay at that

**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 options should be seriously considered.**

**There is no substitute for regular monitoring of your handset display.**

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