

# Digital O2 Cell overview

Jan. 10, 2018

Shearwater Research Inc.

Digital O2 features are intended to address some common issues with the use of O2 sensors in rebreathers.

- Use of cells past expiry date
- Monitoring for early cell failure by recording and observing calibration results
- PPO2 spike to 1.6 test should be done with cells at operating temperature

What are Digital O2 cells?

Digital O2 cells are oxygen sensing chemical cells, created by adding digital circuitry to existing analog cell construction. The Digital enhancements to these cells are constructed in a way that is transparent to traditional usage and operation.

- Digital O2 cells may be used as analog cells
- Digital O2 cells appear to be analog cells to Shearwater SOLO/OBOE boards or Petrel EXT monitor
- There is no battery, the digital circuit portion is completely inactive in traditional circuits
- The analog output is still used as the primary sensing signal for breathing loop control, even in Digital O2 enabled systems
- Digital O2 cells may be phased in and mixed with existing analog cells
- New features are enabled by the use of Shearwater electronics in each O2 cell
- Analytical Industries Inc. is providing Digital O2 cells that use Shearwater electronics and work with Shearwater rebreather control systems

Important: The Digital O2 system is informational and assistive to the diver, but does not perturb or affect the analog cell/loop control – this remains the same as with traditional analog cells. Safety case documentation will not be impacted since there is no change to loop control hardware or firmware. The Digital O2 system will not lock out the diver, since that would be interfering in loop control.



## Digital O2 features

The enhanced features of Digital O2 cells are activated by communication with the Digital circuitry – the communication signal provides very brief power to the circuit on-board the cell. New features enabled:

- Cell type and model may be matched to approved vendor list
- Cell expiry will trigger a (30 day) warning in advance of the expiry date, counting down to expiry
- Expired cells will trigger critical warnings
- Cell calibration history may be stored on the cell and may be viewed for changes in response
- Cell temperature may be read and logged during pre-breathe and dives
- Cell voltage may be read via digital interface and used to validate analog reading (display warning if not in agreement) – this can indicate corrosion or connector problems affecting analog signal, as digital signal is not affected by a few mv offset

The digital interface cannot be disabled but can the diver can use analog cells if desired.

# Digital O2 Requirements

## General

1. Digital O2 circuitry shall not interfere with analog cell operation. -80dB isolation of signal is required.
2. The Digital O2 circuitry shall be passive – unpowered unless activated by the communications interface. This prevents any interference with analog systems and allows the cell to be used as an analog cell in any rebreather.
3. Analog O2 cell outputs shall be used as information for loop control, no changes are required to safety case as the primary functions are not changed. **Digital O2 enhancements are informational and assistive in nature and are not part of the life support control loop.**
4. The Digital O2 system is for diver information and assistance, and **shall not 'lock out' operation of the rebreather.**

## Static information

1. The Digital O2 cell shall report firmware version and memory size when queried.
2. The Digital O2 cell shall store cell identification information – manufacturer ID, cell model number, serial number, manufacture and expiry dates. This information shall be protected from erasure.
3. The Digital O2 cell shall provide a non-volatile storage area for calibration record data.

Current implementation of Digital O2 provides storage for 96 calibrations, with a rolling history if this number of calibrations is exceeded.

## Cell conditions

1. The Digital O2 cell shall measure and report cell temperature.
2. The Digital O2 cell shall measure O2 cell voltage and report over the digital interface (this does not replace the analog reading).
3. The Digital O2 cell shall measure and report its supply voltage (provided by the communications link).

## Digital O2 Cell set-up

Digital O2 cells may be purchased and installed in exactly the same way as analog cells, using the same connector. There is no way to tell a digital cell from an analog cell from the outside, other than the model number. Digital cells may be used as analog cells, as the digital circuit is inactive unless enabled by the specific communication sequence.

It is expected that the Digital O2 cells will have minimal cost increase over analog cells.

Digital O2 feature support is enabled in SOLO2 / OBOE2 hardware now being shipped to OEM customers. Handset and SOLO2 firmware support is planned for release at DEMA 2017. SOLO1/OBOE1 hardware does not support Digital O2 features, although will be able to use the Digital O2 cells as analog cells.

Digital O2 features require low-pass filtering on any analog monitor outputs. Shearwater-supplied board sets have been updated to include this filtering on any analog outputs. For divers that add their own analog outputs, filtering is achieved by adding a 1uF capacitor to ground after 10k isolation resistors between cells and the external connector.

## DiveCAN operation

DiveCAN systems supporting Digital O2 will:

- Check for digital cells at power-up
  - Mix of analog and digital supported, stop polling cells that don't respond to messages
  - Cell expiry, model checked at power-up
- Cell temperature read once per 60s, logged to handset memory
- Calibration procedure reads and compares last stored calibration with new, showing changes
  - Calibration history (including manufacturing test) stored on digital cells

## Start-Up Screen

There are 3 options considered for communication to user of status of Digital O2 cells on each start-up and dive:

<OPTION 1>

- Displayed at startup
- Shows O2 cell types
- Diver confirms types
- Expiry warnings

O2 CELLS			
Cell	Expiry	Days left	
1	17-12-31	124	
2	17-08-31	4 !!	
3	<no reading>		
Date 17-08-27			
			Next

<OPTION 2>

- Digital cells enabled in setup menu

<OPTION 3>

- Digital cell types shown as an icon with PPO2 reading on main center screen

## Warning Messages

	Notification	Static reminder																																				
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## System Screens

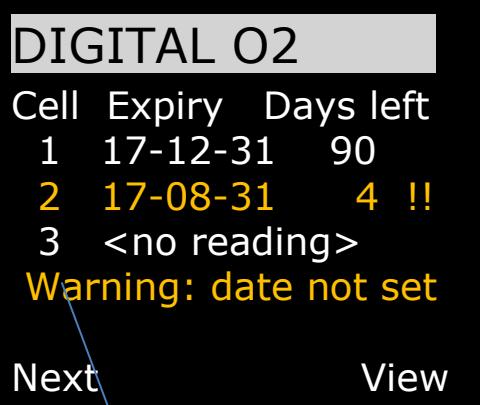
Cells summary

<Only shown if system

Supports digital O2>

Each cell is selectable for

- View more



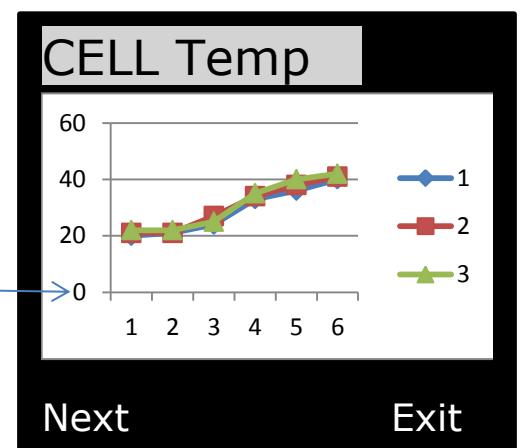
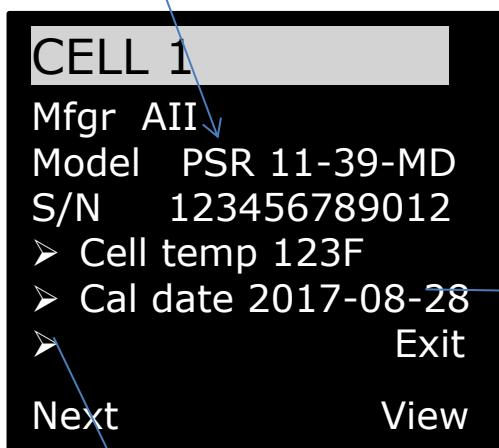
Cell information page

<FUTURE FEATURE>

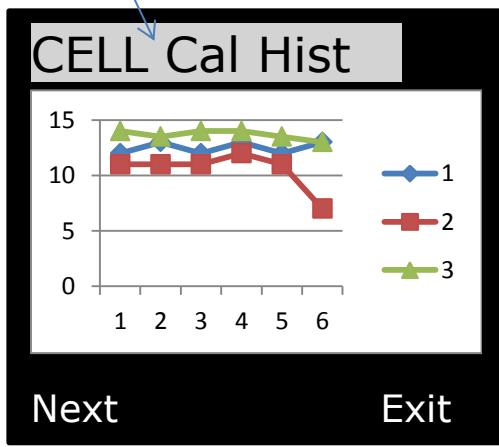
Sub-screens for

- Temperature
- Cal history

Supported in desktop display



<FUTURE FEATURE>



## Real-Time display when diving

Right-button activates  
information display of  
cell temperatures

DEPTH	TIME	SURFACE
.0	24 <sub>h</sub> 00 <sub>m</sub>	
1.01	1.00	0.99
O2	Tmp1	Tmp2
123F	108F	111F