ANALOX O2EII® - Oxygen Analyser

Use of Instrument at Different Altitudes

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Introduction

The Analox O_2EII® analyser displays oxygen in the range 0.0-100.0 %. It is intended for use at atmospheric pressure.

If the analyser is used as recommended in the User Manual, it will work for you in almost all situations. However, at extreme altitudes it may not be possible to achieve the correct calibration. This paper aims to explain to you exactly how the analyser works, and how to use the analyser at extreme altitude if the normal calibration method fails.

Any users still unsure should contact Analox for further advice.

Effect of atmospheric pressure variation

Let us assume that the analyser is calibrated in air to read 20.9% when it is at an atmospheric pressure of 1013.25mBar (Standard atmospheric pressure). If the analyser is then moved to a location with a different atmospheric pressure (but still 20.9% oxygen), then the reading will either rise with increasing pressure, or fall with decreasing pressure. This is because the sensor is sensitive to the partial pressure of oxygen.

At 1013.25mBar pressure, the partial pressure of 20.9% oxygen is 211.77 mBar ppO2 (20.9% of 1013.25).

So by adjusting the calibration knob to make the display read 20.9%, what we are actually doing is normalising the display to read 20.9% for a ppO2 of 211.77.

If the atmospheric pressure increased to say 1030mBar, then the partial pressure of oxygen in the atmosphere would now be 215.27mBar ppO2. The display reading would rise to 215.27/211.77 * 20.9 = 21.2%

Similarly if atmospheric pressure decreased to say 980mBar, then the partial pressure of oxygen in the atmosphere would now be 204.82mBar ppO2. The display reading would fall to 204.82/211.77 * 20.9 = 20.2%.

Increases or decreases in atmospheric pressure are experienced as different weather fronts move across a region. Typically the figures quoted above would only be experienced over a matter of several hours or even days and hence do not interfere with the sequence of an air calibration followed by a check on a bottled sample. Exercise caution if ever you are attempting to calibrate and check a gas bottle in the immediate vicinity of a storm when atmospheric pressure may vary much more dramatically.

Much more extreme cases of low pressure occur simply by taking the analyser to a higher altitude. Remember though that the constant of importance is that fresh air still contains 20.9% oxygen.

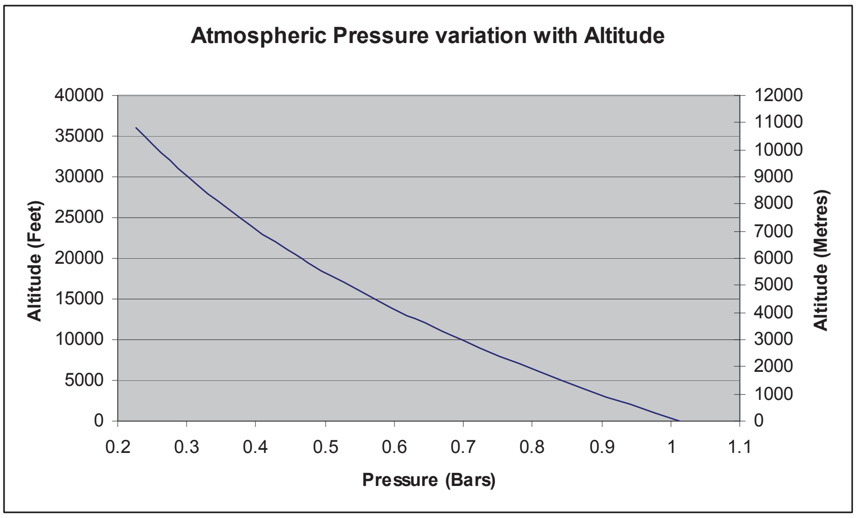
Earlier versions of the O2EII® manual contained a table which stated atmospheric pressure at various altitudes. Table 1 shows a more widely recognised table which we are now using.

So as an example of altitude effects, if the O2EII® mentioned above was calibrated at sea level at standard atmospheric pressure, and then taken to say an altitude of 10000 feet (3048metres), the atmospheric pressure would be 697 mBar, and the partial pressure of oxygen would be 145.67mBar ppO2. The display would read 145.67/211.77 * 20.9= 14.4% oxygen.

Table 1: Atmospheric pressure variation with altitude

Altitude (feet)	Altitude (metres)	Pressure (Bar)	Pressure (kPa)
0	0.0	1.013	101.3
1000	304.8	0.977	97.7
2000	609.6	0.942	94.2
3000	914.4	0.908	90.8
4000	1219.2	0.875	87.5
5000	1524.0	0.843	84.3
6000	1828.8	0.812	81.2
7000	2133.6	0.782	78.2
8000	2438.4	0.753	75.3
9000	2743.2	0.724	72.4
10000	3048.0	0.697	69.7
11000	3352.8	0.670	67.0
12000	3657.6	0.644	64.4
13000	3962.4	0.619	61.9
14000	4267.2	0.595	59.5
15000	4572.0	0.572	57.2
16000	4876.8	0.549	54.9
17000	5181.6	0.527	52.7
18000	5486.4	0.506	50.6
19000	5791.2	0.485	48.5
20000	6096.0	0.466	46.6
21000	6400.8	0.446	44.6
22000	6705.6	0.428	42.8
23000	7010.4	0.410	41.0
24000	7315.2	0.393	39.3
25000	7620.0	0.376	37.6
26000	7924.8	0.360	36.0
27000	8229.6	0.344	34.4
28000	8534.4	0.329	32.9

Figure 1



Does all of this matter?

No not really! We say in the user manual that **“air calibration is essential before every use”**. Why do we say this? It’s not because the oxygen cell specifically needs to be calibrated so often, but it is to ensure that the variability of atmospheric pressure is removed from the equation.

So let’s take our example above at an altitude of 10000 feet.

Air calibrate the O_2EII® at 10000 feet to read 20.9%. This means that we have set up the analyser to display 20.9% for a partial pressure of oxygen of 145.67mBar ppO2.

Let’s assume that we then want to check the contents of a bottle that is believed to contain 40% oxygen and 60% nitrogen. 40% oxygen released to the ambient atmospheric pressure will equate to a partial pressure of 278.8 mBar ppO2. This will cause the analyser (with its just calibrated settings) to read 278.8 / 145.67 * 20.9 = 40.0%.

Surprise, surprise. The analyser reads 40% and we didn’t really need to understand all the calibration factors – we only had to air calibrate to 20.9%.

However, an understanding of what the analyser is doing will hopefully reassure you that it is working correctly. Prior to calibration at 10000 feet altitude, you may have been concerned to note that it was reading 14% oxygen, but as you can see from the above, this is entirely expected.

The converse would happen if you now took the analyser back to sea level from 10000 feet altitude. If you took an air reading before calibrating, you would now expect the analyser to read 211.77/156.67 * 20.9 = 28.3%. No, the atmosphere hasn’t suddenly experienced a dramatic increase in oxygen levels – you simply need to recalibrate to the new atmospheric pressure.

So when would I need to understand all of this?

What we've been saying above is that you really shouldn't have to understand the internal operation of the sensor to measure the percentage content of your oxygen mix. However, as with all types of technical information, there may come a time when you do need to understand it.

In previous versions of the O2EII® manual, we included a section for use at altitude which may have confused some users. What we were trying to say was that at extreme altitudes, you may run out of adjustment of the calibration knob and be unable to obtain a reading of 20.9%. It isn't really possible to state a specific altitude at which this will occur, because it will also depend on the age of your oxygen sensor, and the ambient temperature.

If you can't obtain the required 20.9% figure, then the alternative is to use the display to show the partial pressure of oxygen. Some users assumed they had to do this at altitude irrespective of whether they managed to achieve the 20.9% air calibration.

Using as a partial pressure analyser

You should only have to do this if you are unable to achieve an air calibration as described on page 5. However, there is no reason why you can't use the analyser this way if you want to work in partial pressures. The downside is that you'll probably need a calculator to assist you, whereas if you use the analyser as recommended you will not need a calculator!

So let's go back to some of the locations described above

At sea level and standard atmospheric pressure of 1013.25 mBar, we know that fresh air contains 20.9% oxygen, so we should calibrate the analyser to 20.9% of 1013.25 = 212 mBar (which you can obtain by adjusting the calibration knob to make the display read 21.2. Ignore the fact that the decimal point is on – simply read the display as 212mBar.

Now if you measure a 40% oxygen mix, the reading you will obtain will be 40/20.9* 212 = 405 mBar. Remember we're at 1013.25mBar, so 40% oxygen has a partial pressure of 405.3, so that's exactly what we expect.

Now take the analyser to 10000 feet altitude (697mBar atmospheric pressure). Without re-calibrating the sensor, we would expect it to read 20.9% of 697mBar = 146mBar.

You'll actually find that the analyser needs very little adjustment (if any) to achieve this setting. So let's assume the analyser now reads 146mBar.

If you now test your 40% oxygen mix, we would expect the reading to be 40% of 697mBar = 279mBar. So for the purpose of measuring the oxygen mix if we don't know what it contains, we have to take the partial pressure reading (279mBar) and divide this by the atmospheric pressure to work out the fraction of oxygen in the mix. 279mBar/697mBar gives a fraction of 0.40 (which equates to 40% oxygen).

Conclusions/Recommendations

This paper aims to inform you of exactly how your O_2EII® works. In 99.9% of applications, if you follow our advice to calibrate the analyser every time you use it, then you will not need to understand the complexity of the pressure calculations.

However, in rare circumstances, you may be unable to achieve the required calibration. On such occasions, you could choose not to dive because you are unable to measure your oxygen mix, OR you could continue your diving activities if you use the analyser as a partial pressure analyser. You would have to be prepared to do some calculations, and you may also need a barometer, but if you understand the notes, there is no reason why you can't measure your oxygen mix safely and accurately.