# Using MTL Zirconia Oxygen Analysers to Measure the Dewpoint of Furnace Atmospheres

**A MTL Zirconia Oxygen Analyser will measure dewpoint only under certain conditions:**

**1) that the gas to be measured contains a known amount of hydrogen;**

**2) that the balance of the gas is either nitrogen or inert. As a result it works in pure hydrogen, cracked ammonia, and hydrogen/argon or hydrogen/helium mixtures, but not in carburising gases, which also contain $CO/CO_2$, although very useful measurements can be made in these atmospheres too - see Technical Note TN03.**

In order to appreciate the advantages of using MTL zirconia oxygen analysers to monitor furnace atmospheres, it is helpful to understand why in such atmospheres the dewpoint is measured. The measurement of the dewpoint of a gas is, in reality, just a way of measuring its water content. The reason this is important is because too much water in the furnace atmosphere will spoil the work going through it; not because of the water itself but because, at the high temperatures within a furnace, it dissociates into hydrogen and oxygen. This is illustrated by the following chemical equation:

$$2H_2O = 2H_2 + O_2$$

It is the oxygen that then reacts with the work in the furnace causing staining or scaling. At any given temperature the ratio

$$\frac{p^2[H_2] \times p[O_2]}{p^2[H_2O]}$$

is a constant. (p is the concentration or activity of the reactant in the bracket). Similar equations can be written to describe a metal in equilibrium with oxygen. The values of the constants are well defined by standard data. In fact, what is happening inside the furnace is a kind of competition between the contents, say iron and hydrogen, for the oxygen. At any particular temperature, a metal will have a precise oxygen concentration, or activity, at which it will oxidise. If the oxygen activity is kept below that point, no oxidation will take place, and vice versa. What the formula illustrates is that by adding more hydrogen to an atmosphere, the oxygen activity is reduced. This is because the only way the ratio of activities can be maintained constant, as determined by the laws of chemistry, is by the oxygen decreasing and/or the water increasing. Adding more hydrogen is a standard cure for overcoming problems when the water content (dewpoint) becomes too high.

This is why furnace operators always wanted the dewpoint to be measured; because, in less enlightened times, it was the only way to determine how much oxygen was in the furnace. To avoid the complication of translating this figure into oxygen concentration, the atmosphere quality used to be expressed in terms of dewpoint and hydrogen concentration.

The key factor however is oxygen, and its activity, and MTL zirconia oxygen analysers measure this directly. The zirconia sensor is uniquely capable of measuring the extremely low concentrations of oxygen to be found in these atmospheres. For convenience, some analysers can be fitted with a meter scaled in dewpoint. However there is no real reason to have the analyser scaled in dewpoint; we offer it only because some users are used to it. It could be scaled in parts per million of water vapour, sensor millivolts or, more pedantically, in oxygen potential; the figure that the user really needs to know. Oxygen potential is no more than the oxygen activity expressed in chemical units. As such it relates easily to the oxygen values that a chemist would use when determining the point at which a metal would oxidise at a particular temperature. All of our microprocessor based analysers of this type display in oxygen potential (kilo-calories or kilo-joules). See Technical Notes TN01 & TN03 for a fuller explanation of zirconia oxygen cell theory, etc.

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# Zirconia Oxygen Analysers

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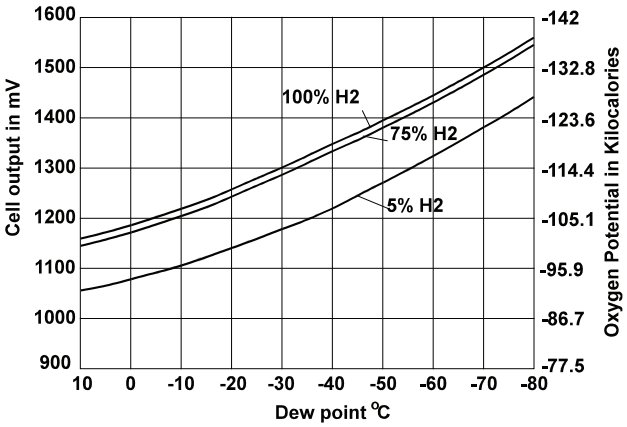
| Dewpoint | | ppm $H_2O$ | Cell output in mV (634°C) | | |
|---|---|---|---|---|---|
| °C | °F | | 100% $H_2$ | 75% $H_2$ | 5% $H_2$ |
| 0 | 32 | 6025 | 1192 | 1180 | 1076 |
| -10 | 14 | 2566 | 1227 | 1215 | 1110 |
| -20 | -4 | 1021 | 1256 | 1244 | 1140 |
| -30 | -22 | 376 | 1302 | 1291 | 1186 |
| -40 | -40 | 127 | 1346 | 1334 | 1228 |
| -50 | -58 | 39 | 1392 | 1380 | 1274 |
| -60 | -76 | 10.6 | 1442 | 1432 | 1326 |
| -70 | -94 | 2.55 | 1498 | 1487 | 1382 |
| -80 | -112 | 0.53 | 1560 | 1549 | 1443 |

The table shows the relationship between dewpoint and the water concentration, and also gives the related output in millivolts of the MTL zirconia oxygen sensor in various concentrations of hydrogen.

The graph below illustrates the relationship of dewpoint to cell output and oxygen potential at various concentrations of hydrogen.




**Note**: The **MTL Z210 and MTL Z1110** analysers are used for this type of application.

## Additional related Technical Notes:

TN01 - *"Oxygen sensors - theory and application"*

TN03 - "*The Use of Zirconia Oxygen Analysers in Heat Treatment"*

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