

In-Situ Zirconium Oxide Measurement vs. Other Methods

Oxygen concentration measurements are highly dependent on the instrumentation. While this can be a concern to end-users, the differences are readily explained. The objective of this Technical Note is to explain the causes of these differences and how the various measurement methods can affect the reported oxygen concentration.

Net Versus Gross Measurement

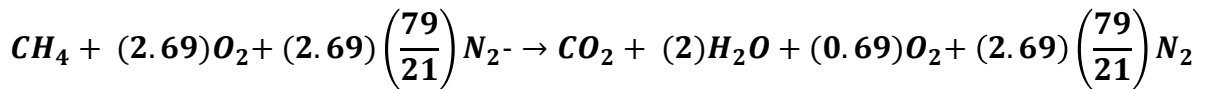
The total amount of oxygen present in flue gas after combustion is considered the “gross” measurement. A “net” measurement is made only when complete combustion has occurred. Very often, a less-than-ideal ratio of fuel to oxygen occurs in a burner, leaving combustibles and extra oxygen in the flue gas. Methods such as Orsat analysis, wet electrochemical cells, or paramagnetic cells provide gross measurements. On the other hand, the zirconium oxide cell used in Yokogawa’s ZR series of oxygen probes operates at a temperature that is high enough to burn any remaining combustibles and, thus, yields a net measurement of oxygen. The net measurement can range from a few parts-per-million to a few percent lower than the gross oxygen measurement.

Wet Versus Dry Measurement

The products of simple combustion of a hydrocarbon fuel are carbon dioxide and water. Water vapor present in the flue gas is extracted to obtain a cool, “dry” sample via most methods for oxygen analysis. Zirconium oxide analyzers are unique in the respect that the sample gas remains heated with the water vapor present; thus it is considered a “wet” measurement.

The following example applies to the combustion of methane with a wet flue gas oxygen concentration of 5%:

The balanced equation for total combustion:



Reporting a wet measurement considering that volume percentage is equal to molar percentage for a vapor:

$$\frac{(0.69)O_2}{CO_2 + (2)H_2O + (0.69)O_2 + (2.69)\left(\frac{79}{21}\right)N_2} = 5.00\% O_2$$

Reporting a dry measurement with the same considerations:

$$\frac{(0.69)O_2}{CO_2 + (0.69)O_2 + (2.69)\left(\frac{79}{21}\right)N_2} = 5.84\% O_2$$

It can be seen that a significant increase in oxygen (17%) is reported when using a dry measurement vs. the wet measurement.

OpreX™ Through the comprehensive OpreX portfolio of products, services, and solutions, Yokogawa enables operational excellence across the enterprise.

Trademarks Co-innovating tomorrow, OpreX and all product names of Yokogawa Electric Corporation in this bulletin are either trademarks or registered trademarks of Yokogawa Electric Corporation. All other company brand or product names in this bulletin are trademarks or registered trademarks of their respective holders.

YOKOGAWA ELECTRIC CORPORATION
World Headquarters
9-32, Nakacho 2-chome, Musashino-shi, Tokyo 180-8750, JAPAN

<http://www.yokogawa.com>



YOKOGAWA CORPORATION OF AMERICA
YOKOGAWA EUROPE B.V.
YOKOGAWA ENGINEERING ASIA PTE. LTD.
YOKOGAWA CHINA CO., LTD.
YOKOGAWA MIDDLE EAST & AFRICA B.S.C.(c)

<http://www.yokogawa.com/us/>
<http://www.yokogawa.com/eu/>
<http://www.yokogawa.com/sg/>
<http://www.yokogawa.com/cn/>
<http://www.yokogawa.com/bh/>

Subject to change without notice.
All Rights Reserved, Copyright © 2021, Yokogawa Electric Corporation