



Optimize Furnace Efficiency and Increase Throughput while Minimizing Emissions

Control Energy flow for optimal combustion with fast-responding feed-forward control

Fuel gas feed to furnaces, turbines and boilers can vary frequently and suddenly in composition. These changes will immediately affect the operating stability and efficiency of the combustion process and cause unwanted emissions.

By installing a fast responding WIM Compas analyzer in the fuel gas supply line, the Gas flow and/or Air requirement can be controlled before the actual combustion takes place, with a feed forward signal from the analyzer. Disturbances are minimized and the combustion process occurs with maximum efficiency and minimum emissions.

The WIM Compas measures the Wobbe Index and the Combustion Air Requirement Index (CARI) separately, enabling

- **monitoring / control of fuel gas flow and / or gas quality using the Wobbe Index.** For large fluctuations in the fuel gas composition, the Wobbe index can be stabilized, and fuel gas management stabilized, using the fast-responding Wobbe Index signal. The WIM Compas has a particularly fast response time ($T_{90} < 5$ seconds)
- **Air-Fuel ratio control using the CARI** – this note explains why both Wobbe Index and CARI should in general be used for this purpose. The WIM Compas is particularly accurate, even with large fluctuations in H₂ and/or CO levels.

The WIM Compas offers the above control benefits with maximum availability, reliability, installation convenience and minimal maintenance. Do not compromise on quality!

Optimizing combustion efficiency using Wobbe Index and / or Combustion Air Requirement Index (CARI).

In many refineries and petrochemical plants, furnaces and boilers can be exposed to frequent and sudden changes in the fuel gas composition. These changes will immediately affect the operating stability causing loss of efficiency and increasing emissions.

A simplified combustion process is indicated in the figure below.

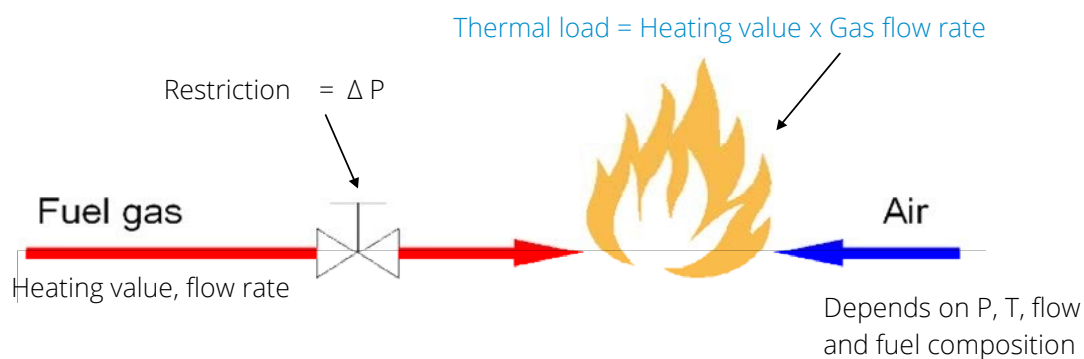
The gas flow through a restriction fluctuates with the specific gravity of the fuel gas. A sudden change in composition (Specific gravity) will affect both the Heating value and the gas flow rate. This results in a change in thermal load and combustion air requirement.

The Wobbe Index is a measure of the interchangeability of gas when fluctuations in gas composition and/or specific gravity are expected. Two gases with different composition but with the identical Wobbe Index produce the same amount of energy when burned:

$$\text{Wobbe Index} = \frac{\text{Heating Value}}{\sqrt{\text{Specific gravity}}}$$

Likewise, for the combustion air requirement CARI is the required amount of dry air for the stoichiometric combustion of 1 Nm³ of fuel gas compensated for the specific gravity of the gas:

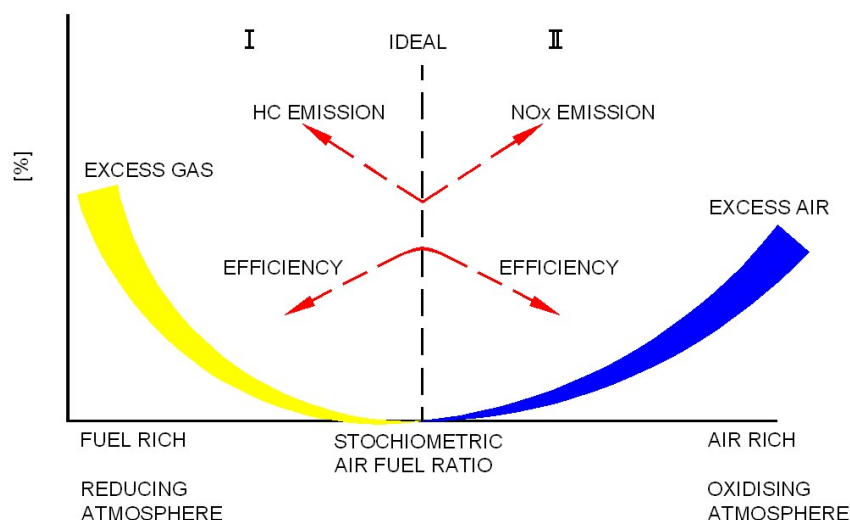
$$\text{CARI} = \frac{\text{Air Demand}}{\sqrt{\text{Specific gravity}}}$$



Air / Fuel ratio control

Plant operators look for methods to stabilize the energy flow and control the air/fuel ratio in such a way that the disturbances are minimized and the combustion process operates with maximum efficiency. For this reason, feed-forward air / fuel ratio control is the only way to go when fluctuations in gas composition are expected. As combustion processes are among the most complex and fastest processes in the industry: never compromise on the response time of the measurement.

The figure below shows the influence of the air/fuel ratio on combustion efficiency and possible emissions. The black dotted line indicates the stoichiometric air/fuel ratio (the exact amount of air required for the combustion of 1 m³ of gas under normal conditions). This is the most efficient way to burn your fuel gas and to minimize NO_x or hydrocarbon (HC) emissions.



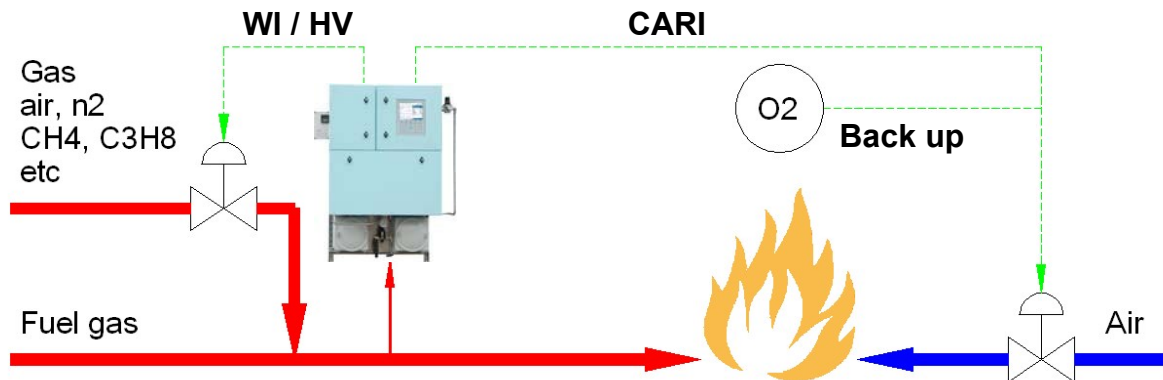
Why use both CARI and Wobbe index for Air / Fuel ratio control?

Both the energy content and the air required for combustion depend on changes in gas composition. As indicated in the example below, both CARI and Wobbe can vary independently. The Heating value of mix 1 and mix 2 are the same. Nevertheless, burning these gases under similar conditions will result in a different thermal load due to the difference in specific gravity (and therefore gas flow and Wobbe Index).

The Wobbe Index of mix 2 and 3 is the same, and therefore, the energy produced will be the same for combustion under similar conditions. However, due to the presence of hydrogen (H₂), which requires less air for combustion than methane, the air requirement of mix 2 is much less.

For this reason we recommend using the Wobbe Index signal for stabilization of the energy flow, and the CARI signal for feed forward air/fuel ratio control.

	Mix 1	Mix 2	Mix 3
Methane (vol %)	58	40	-
Hydrogen (vol %)	-	60	87.9
Nitrogen (vol %)	42	-	12.1
Heating value (MJ/Nm ³)	20.8	20.8	31.5
Wobbe Index (MJ/Nm ³)	24.4	40.6	40.6
Specific Gravity	0.73	0.26	0.61
CARI	6.5	10.2	10.8
Air Demand (Nm ³ air / Nm ³ gas)	5.6	5.3	8.4



Important

Wobbe Index analyzers / Calorimeters typically correlate the CARI to the Wobbe index. This correlation is correct provided that the gas composition does not include hydrogen or carbon monoxide (CO). Both H₂ and CO require less air for stoichiometric combustion than for instance, alkanes. Therefore, if H₂ and CO are present correlating Wobbe index to CARI will result in inaccurate readings, loss of efficiency and increasing emissions!.



The Hobre WIM COMPAS™ measures both Wobbe Index and CARI separately! Since CARI measurement is related to the residual oxygen after complete combustion of the sample gas, CARI is directly measured and an accuracy of +/- 0.4% F.S. is guaranteed. This is also the case if large fluctuations in H₂ and/or CO occur.

Points to note

- Response time is key, you need the best available. A fast-responding feed-forward signal to optimize your fuel gas management is the reason for installing Hobre WIM COMPAS™.
- Always use independently-measured Wobbe and CARI values for fuels containing for H₂ and / or CO containing fuels.
- In control applications, availability, reliability, installation convenience and cost and low maintenance cost are important. The Hobre WIM COMPAS™ will improve efficiency without causing extra maintenance. Do not compromise on quality.
- Make sure you know how the flow is measured: where the specific gravity is available from the flow meter you most likely do not need the integrated SG meter to convert to Heating value.
- Consider the response time of the system as a whole in choosing the analyzer location of analyzer installation.