



Stara Glass – More than 60 years of high performance

# High-Efficiency Air-Staging



A simple and effective primary  $\text{NO}_x$  containment technique  
for regenerative glass furnaces

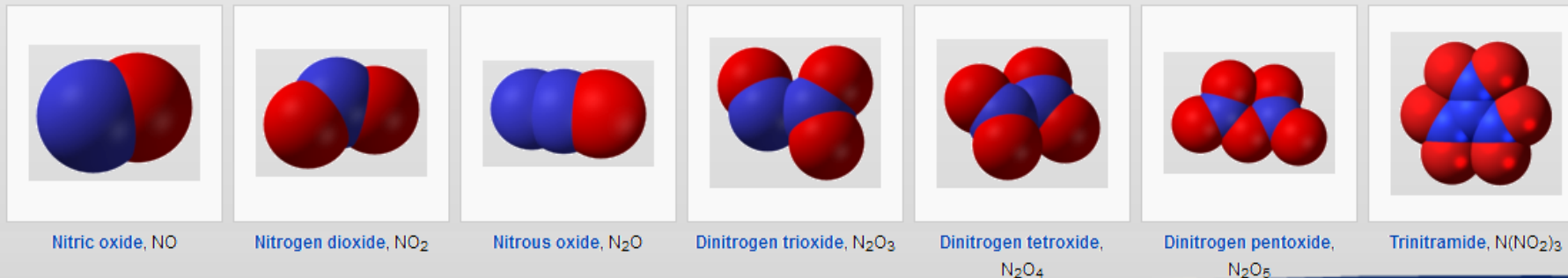


Nitrogen oxides are atmosphere pollutants and it is believed that they aggravate the conditions of people suffering of asthma. Some of them, in presence of solar radiation, can react with oxygen forming ozone and other compounds of the so called photochemical smog, if in presence of unburned hydrocarbons (HC). Nitrogen trioxide and pentoxide can form nitrous and nitric acid, responsible of *acid rains*. To protect environment and life, the legislation on industrial NOx production is worldwide becoming more and more restrictive.

**The two conditions that increase the NOx production in a combustion are:**

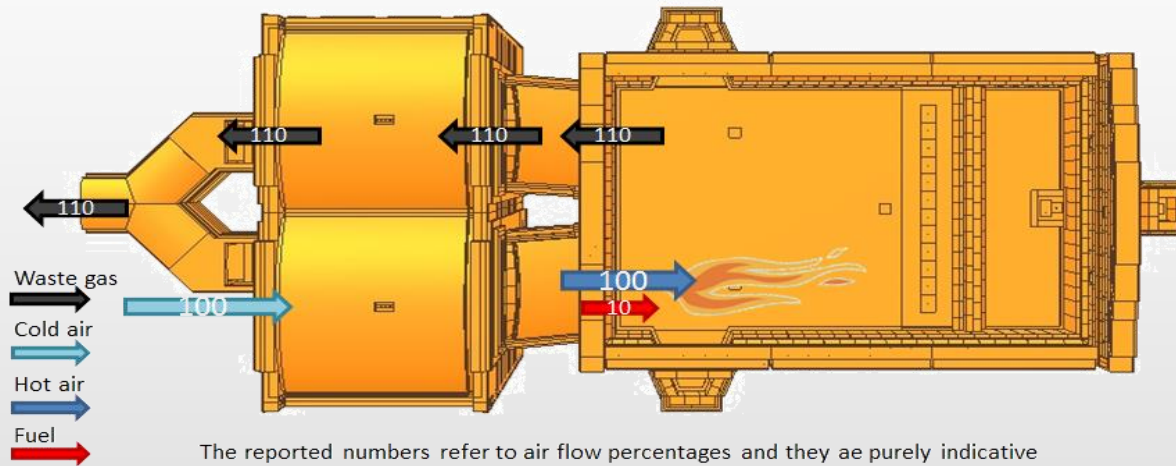
- **Oxygen concentration**
- **High temperature**

**Regenerative furnaces generate a high concentration of NOx** and, since a high temperature of air is desired and directly connected to energy saving, **the first primary action that is commonly taken to contain this generation is a reduction of the air/fuel ratio.** The impact of this measure, besides a limited loss of energy efficiency, is a **jeopardization of regenerative chamber's checkers**, above all if these are made in magnesite, due to the consequent presence of CO in the waste gas.



A consolidated technique that Stara Glass tested and proposes for operating regenerative glass furnaces consists in the developing of a **less-than-stoichiometric combustion inside the combustion chamber and a combustion completion in the port-neck** by the usage of an external ambient-air flow.

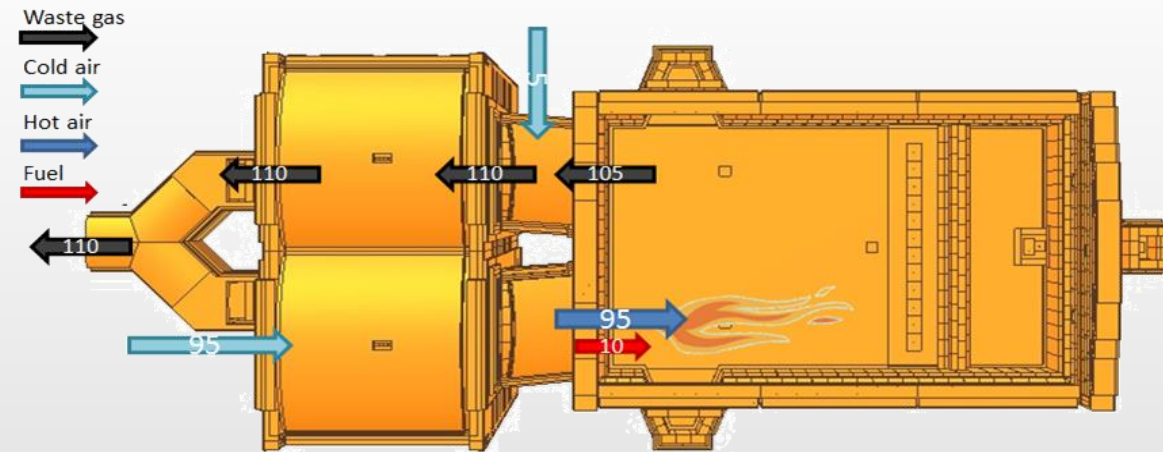
## Common end-port furnace



## Pros

- Applicable to running furnaces
- Up to -40% NO<sub>x</sub> (field results)

## Cold air-staging

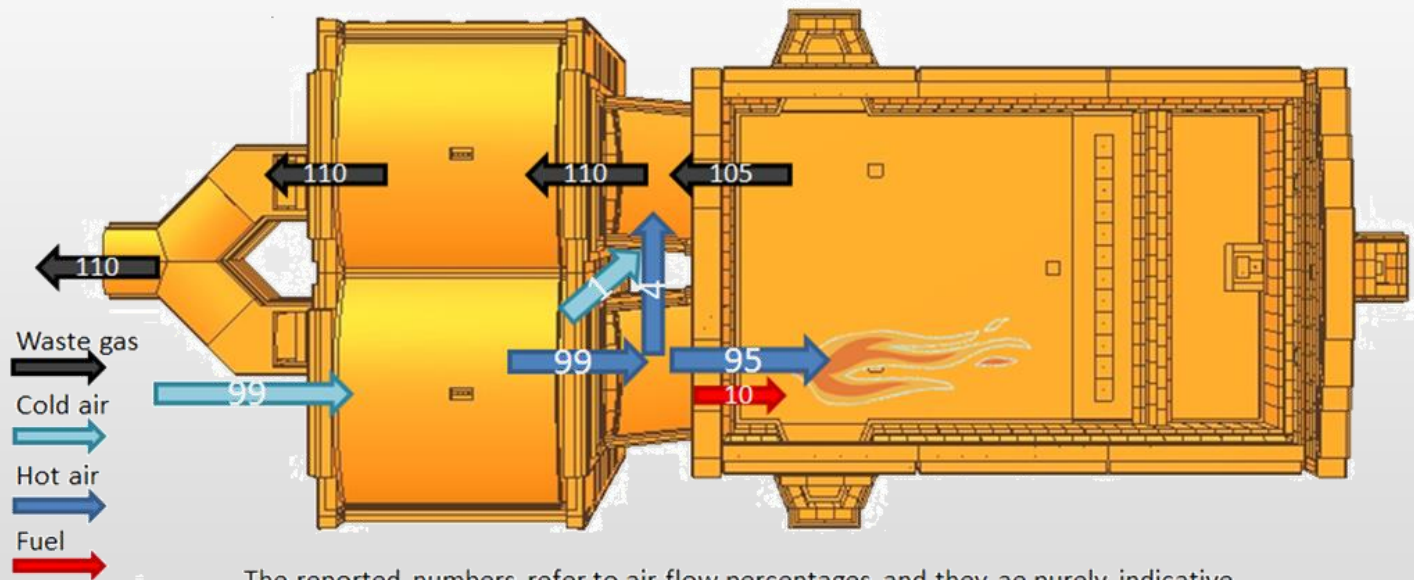


## Cons

- -3/-5% energy efficiency decrease, due to the utilization of cold air

Within the Prime Glass project ([www.primeglass.it](http://www.primeglass.it)) **Stara Glass developed and patented a staging technique** that guarantees the same abatements of the cold air-staging with a significantly more contained energy loss: a connection between the two ports is installed and the natural pressure gradient between them, aided by a minor cold air inlet (about 10-15% of the total flow volume) allows to **reduce the energy loss to about -1%.**

## Hybrid high-efficiency air- staging



### Pros

- -0,5/-1,5% energy efficiency decrease
- Up to -40% NOx (field results)

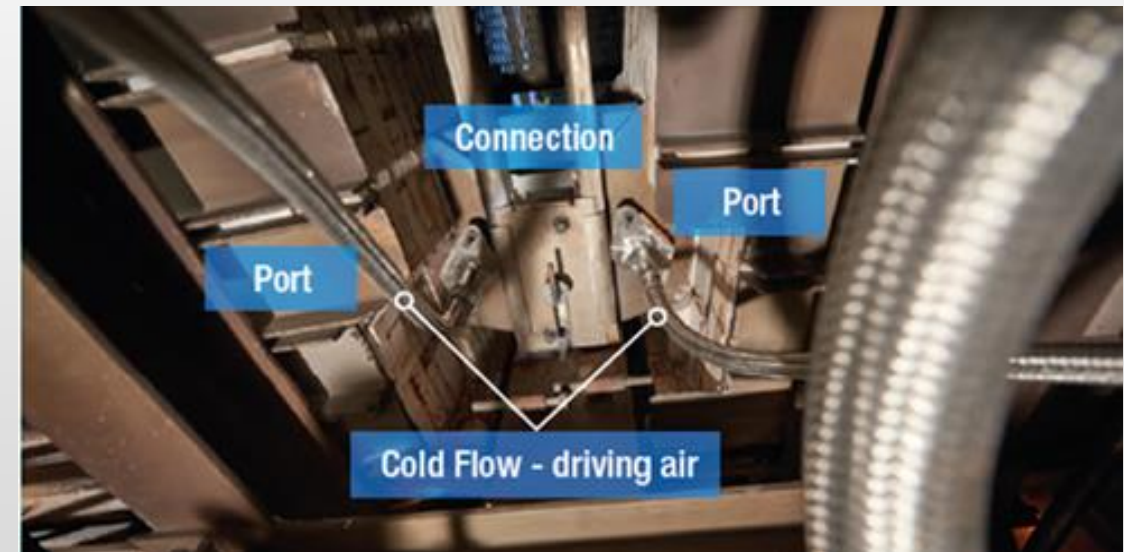
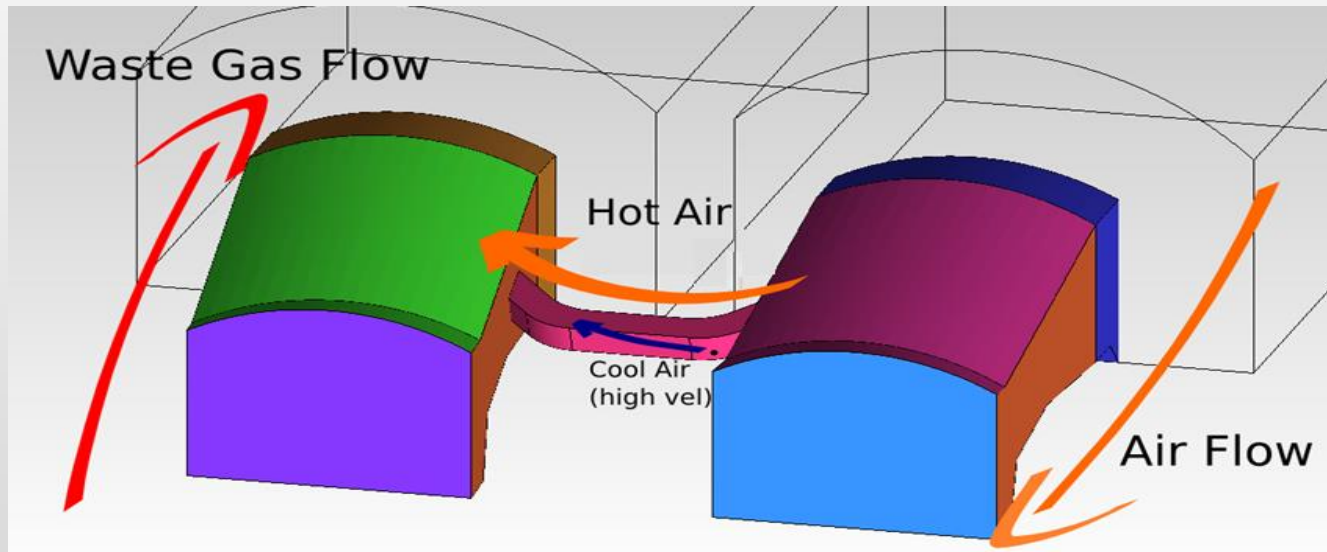
### Cons

- The installation is possible only during a furnace rebuilding



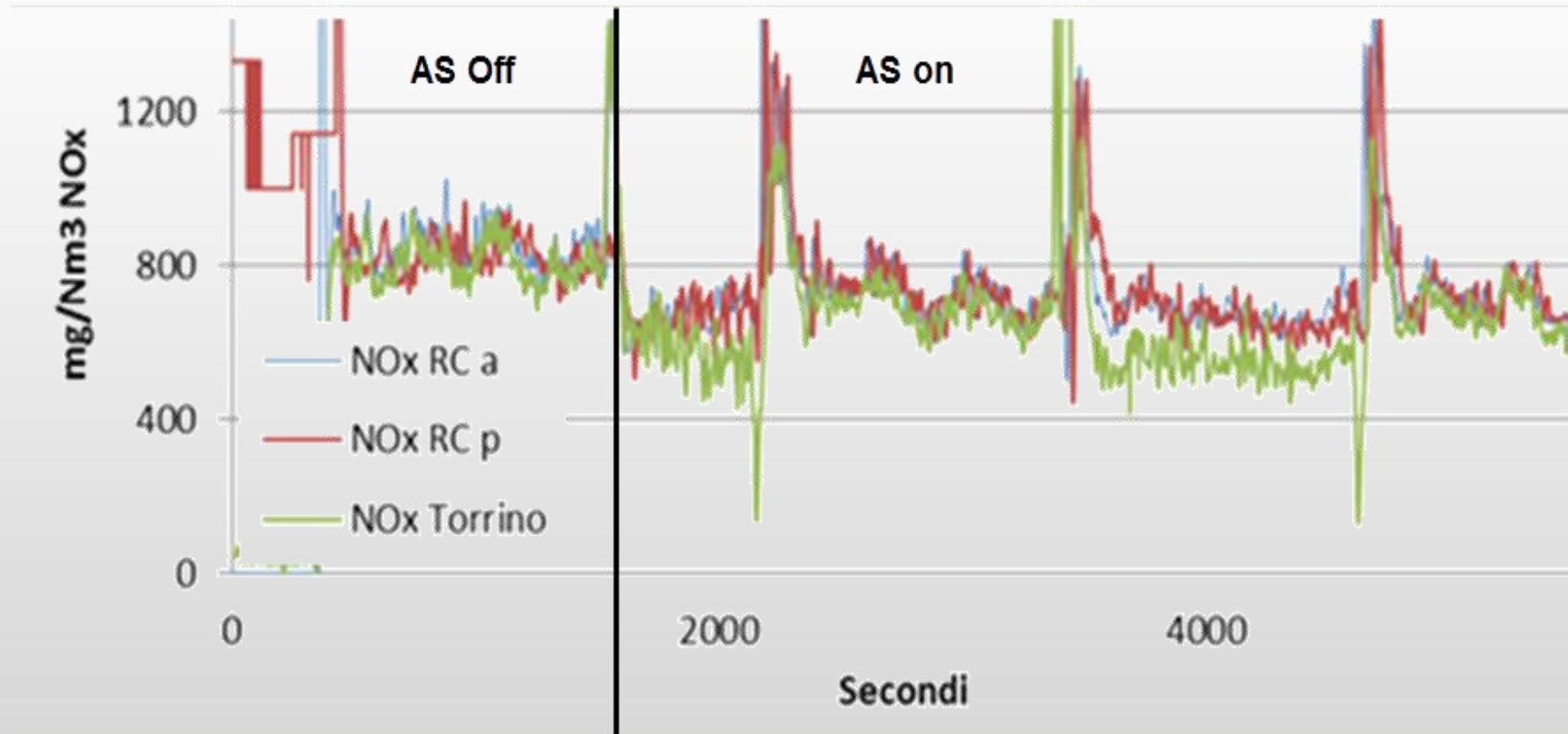
The system, that is custom-designed and **CFD-optimized** for every installation, consists of:

- Port connection CFD-aided design in different operating conditions,
- Refractory connection between the ports with its insulation,
- Refractory valve to open and close the connection,
- Piping for cold air,
- Control panel connected to the furnace control system.



## High-efficiency air-staging: abatement results

In the chart the results of a high-efficiency air-staging application (**about -40% NO<sub>x</sub>**). Depending on the abatement needs of the customer, it is possible to regulate the system in the direction of higher or lower abatements, with the consequent impact on the energy efficiency of the furnace.



The HEAS technology has been used for:

- **Bormioli Rocco** (Prime Glass project experimental installation)
- **O-I**
- **Solvay**
- **Vetreria Etrusca**





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**Stara Glass S.p.A.**

**P.zza Rossetti 3A/1 - 16129 Genova – Italy**

**+39.(0)10.57639.1**

**[www.staraglass.com](http://www.staraglass.com)**

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