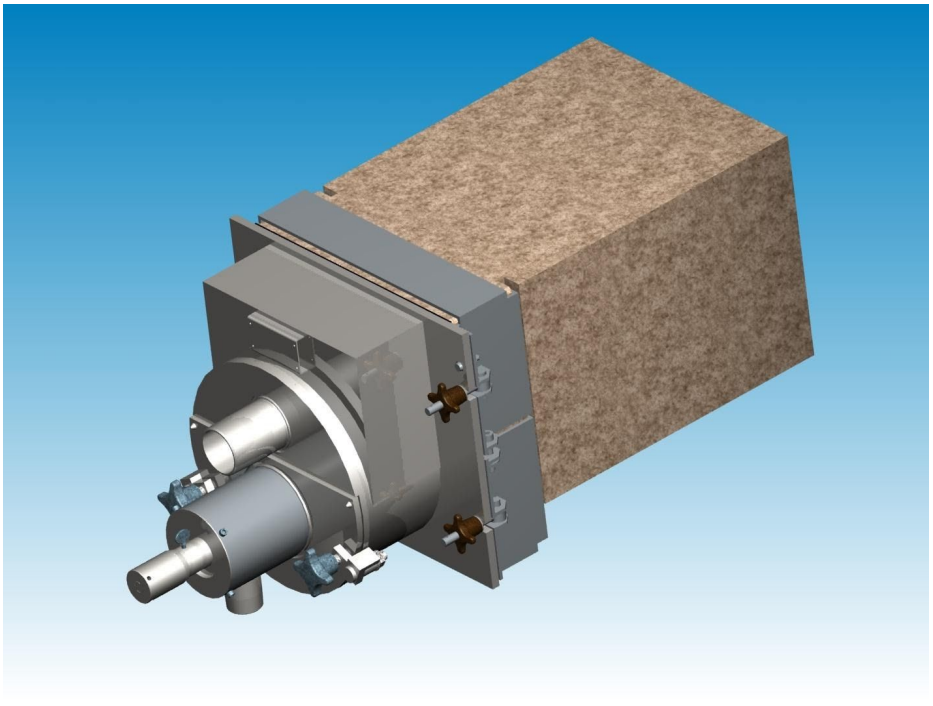
ALGLASS FC VM BURNER

Natural gas version

SAFETY INSTRUCTIONS FOR INSTALLATION, USE AND MAINTENANCE



Thank you for the trust you have expressed by purchasing this equipment, which will give you full satisfaction if you follow its instructions for use and maintenance.

The manufacturer will not be held responsible where items not recommended by themselves are associated with this product.

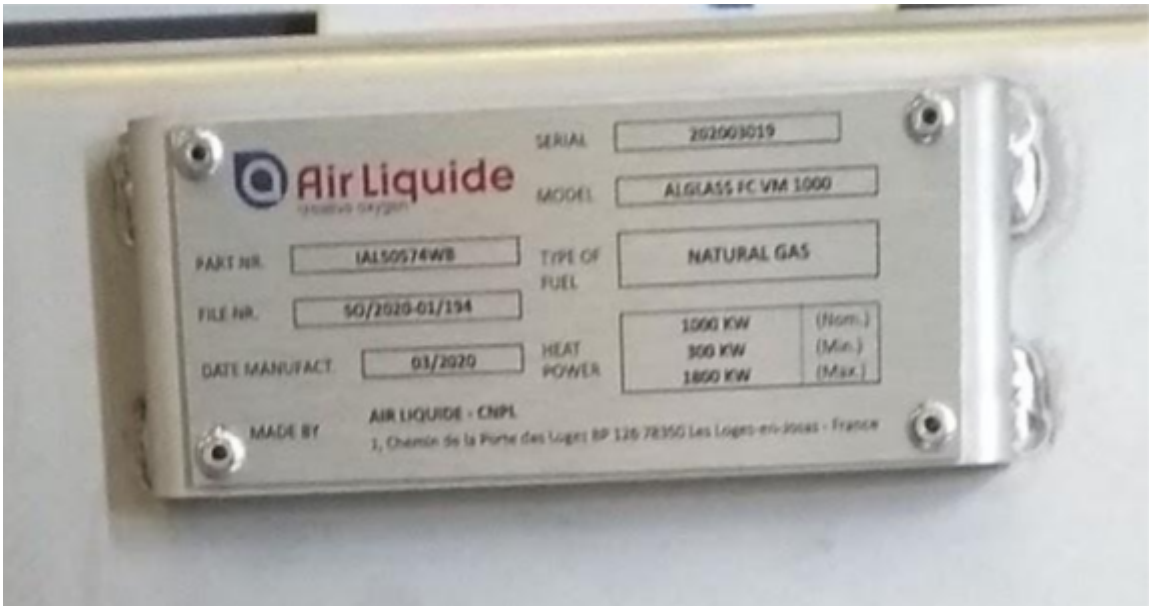
For your safety, there follows a non-restrictive list of recommendations or requirements, many of which appear in the employment code.

Finally, we would ask you kindly to inform your supplier of any error which you may find in this instruction manual.

CONTENTS

A . IDENTIFICATION PLATE - EXAMPLE

The plate below is fixed on the body of the ALGLASS FC VM GAS BURNER unit, it is used to identify it. This is an example of the plate and informations mentioned on it :



Please, use these informations in all correspondences.

B . SAFETY INSTRUCTIONS

Every operator who manipulates the oxy-fuel ALGLASS FC VM burner should be trained on oxygen safety procedures. In particular, operators must be aware of the following minimum safety instructions for oxygen use:

- **Never use oil or grease for oxygen piping, nor assembling burner parts.**
- **Do not use organic materials for tightness components.**
- **Always clean all parts before installing them.**
- **Operators training for oxygen use.**

Failure to respect these instructions may cause ignition in the oxygen circuit, and further propagation along the oxygen piping.

C . INTRODUCTION

The ALGLASS FC VM is a burner specially developed for glass furnaces, which combines all the benefits of oxygen firing in a radically new design aimed at improving furnace efficiency. Fuel and oxygen are introduced in the furnace through a unique configuration of injectors, which produces a highly luminous flame up to three times wider than conventional oxy-fuel burners.
The standard ALGLASS FC VM burner is available in four sizes: 200, 500, 1000 and 2000 kW.
Demonstrated benefits of the new burner technology are:

- improvements in fuel efficiency with a flame energy directed to the glass rather than the furnace superstructure,
- improvements in heating uniformity and elimination of hot spots through enhanced bath coverage,
- high luminosity for efficient heat transfer to the glass,
- low pollutants emissions.

Burner operation

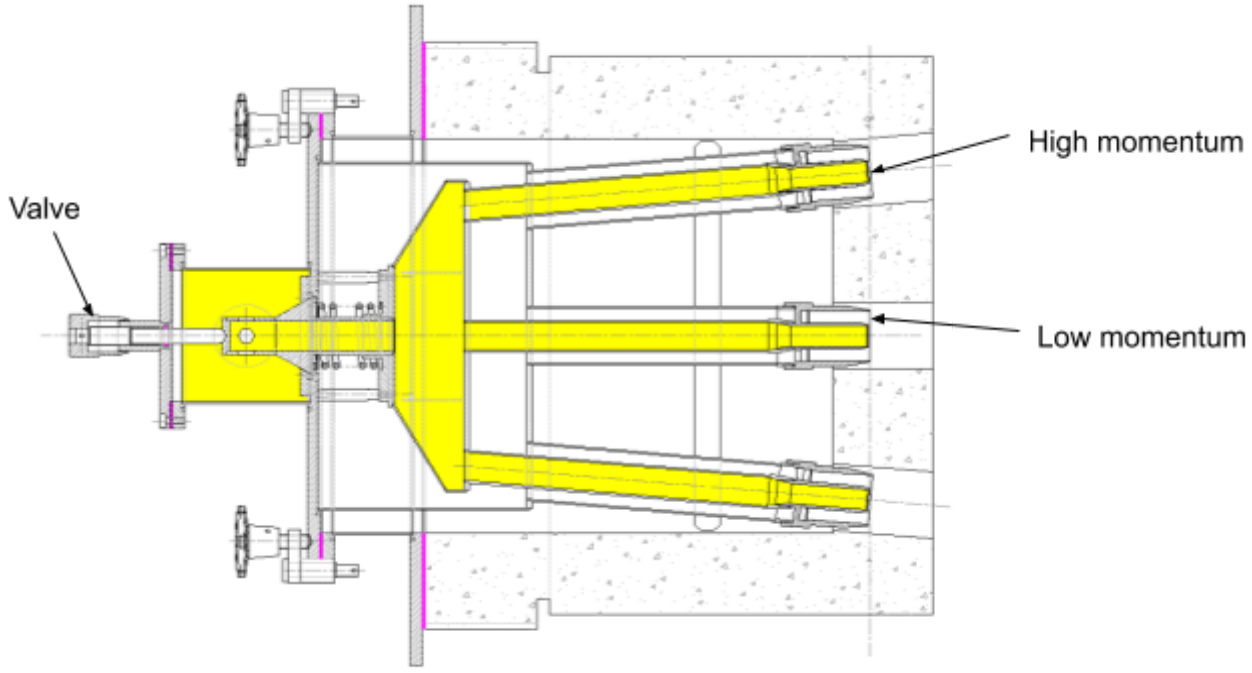
In conventional gas-cooled oxy-fuel burners, a stream of fuel gas surrounded by a parallel stream of oxygen is partially combusted in a burner block cavity (of cylindrical or rectangular shape), then ejected in the furnace in a jet of hot gases. Because fuel and oxygen are mixed inside the burner block and react immediately, the combustion is very intense, resulting in a high peak temperature flame.

The ALGLASS FC VM burner (patents pending) uses a totally different design where fuel and oxygen mix outside the burner block. The fuel is distributed at the bottom of a refractory burner block among three double natural gas injectors arranged in a fan-shaped configuration, so that the streams of fuel form a wide sheet of gas in the furnace.

Oxygen is injected at lower velocity from two orifices located at the top of the block, which direct the oxygen flow towards the jets of fuel. The result is a wide and luminous flame, covering the glass melt.

The design of the double natural gas injector consists of two concentric injectors: inner (high momentum) and outer (low momentum).

A valve, positioned upstream of the natural gas lance is used to tune the momentum of the gas stream between low momentum (outer injection) and high momentum (inner injection).



This design with double natural gas injectors allows to:

- Adjust flame shape and more generally combustion characteristics in regard of industrial combustion chamber constraints for a given power.
- Operate the burner over a wider power range. For instance, the ALGLASS FC VM 1000 burner can operate from 300 up to 1800 kW.

Note:

Optional improved control of the flame shape and luminosity can be obtained by injecting a small part of the oxygen flow (for a total of 3% to 15% of the combustion oxygen) around each of the three double

natural gas injectors at the bottom of the block, in a pipe-in-pipe configuration. Increasing the secondary oxygen flow results in faster mixing between gas and oxygen and a shorter flame. With low secondary oxygen flow, mixing between oxygen and gas is delayed, which yields a longer flame. In both situations, the flame peak temperature is reduced because the oxygen and fuel jets are diluted with the furnace gases before they intersect. The energy released by the partial combustion of the natural gas with the secondary oxygen helps the thermal decomposition of the fuel, and formation of carbon particles that are highly radiant.

D . DESCRIPTION

The ALGLASS FC VM burner is composed of (see figure below):

(1) Natural gas fuel lance, with 3 tubes, equipped with a valve for controlling flows.

(2) 3 injectors for inner injection – with high momentum – of natural gas.

(3) 3 screwed injectors for outer injection – with lower momentum – of natural gas.

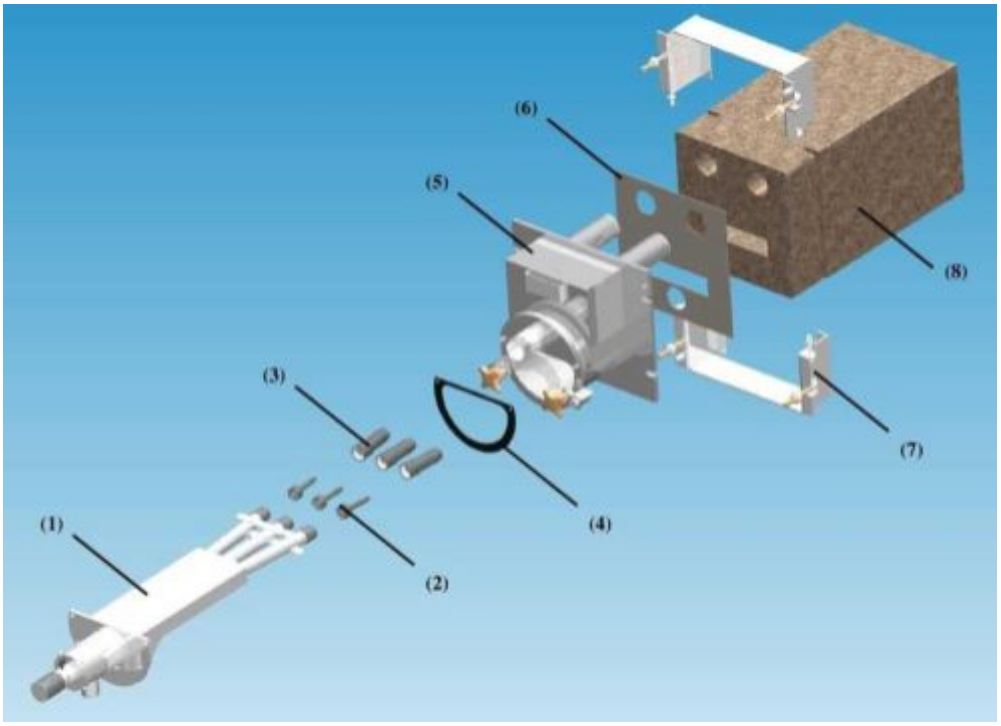
(4) Flat Viton sheet gasket.

(5) Burner body.

(6) Ceramic fiber gasket positioned between the burner block and the burner body.

(7) Bracket adapter composed of 2 parts, for installing the burner body on the burner block.

(8) Burner block made of refractory material.



All of the materials used for the burner fabrication are compatible with pure oxygen. All the burner metallic parts must be clean of dust and oil.

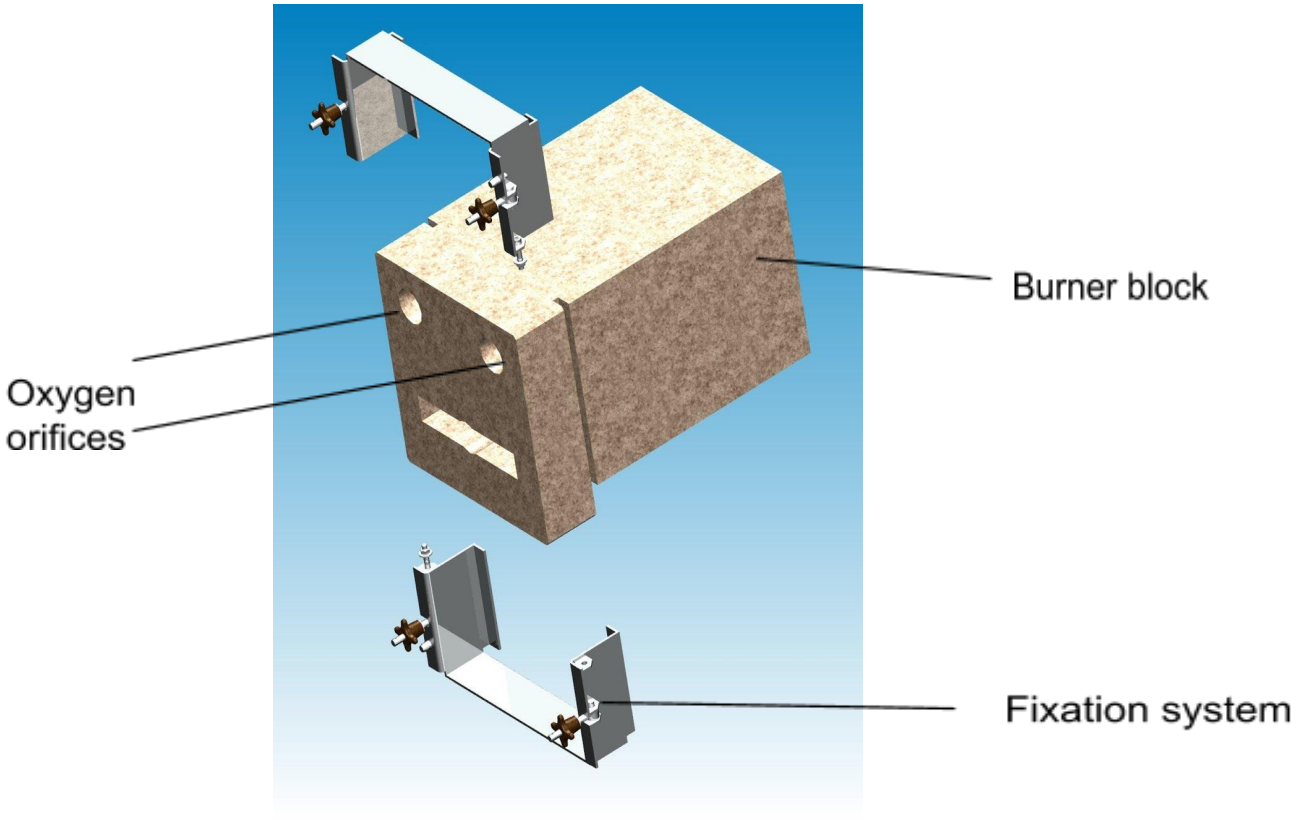
E . INSTALLATION OF THE BURNER

Before installing the block inside the furnace wall, proceed to a blank assembling of all burner parts to verify the centering of NG nozzles inside the block hole.

1. Installation of the bracket adapter

Warning: the bracket adapter (2 pieces) must be mounted on the burner block before the block is installed in the furnace wall except if rear part of block is outside the furnace wall and there is enough room for brackets installation above and below the block.

The fixation system is in two parts: it is assembled with the supplied set of nuts and bolts.



2. *Installation of the burner block*

The block has 2 oxygen orifices and 3 gas orifices.

Before installing the burner block, check that the support of the block is horizontal or inclined no more than 2° to 5° toward the glass surface, to make sure that flames are not oriented towards the crown of the furnace.

In order to be sufficiently protected from the furnace radiation, the burner block outlet face must be placed in the same plane as the inner furnace wall or slightly in recess (1-2 cm).

Good tightness of the burner block mounting in the wall is essential to limit air inlets near the burner and reduce the formation of nitrogen oxides. It is recommended that the blocks are mounted with small refractory wedges and / or fibrous refractory sheets. Mortaring the blocks in place would be most desirable.

New furnace (cold installation)

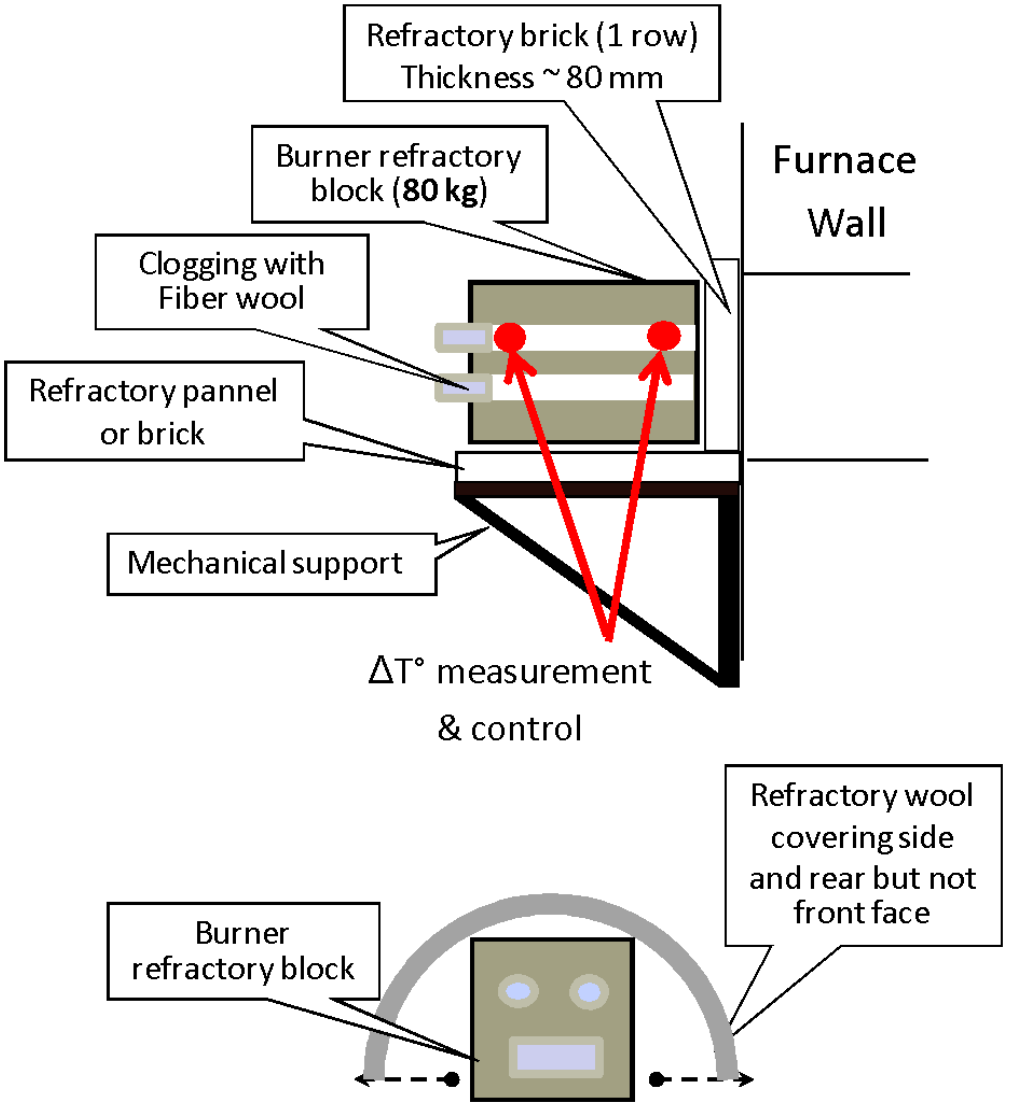
- Place the burner block with its bracket adapter in the dedicated furnace opening. Make sure that the two oxygen orifices are above the natural gas orifices and horizontal before pushing the block into final position (block outlet face in the same plane as the inner furnace wall).
- If the burner is not installed before several hours, plug the holes (natural gas and oxygen) in the block with alumina wool.
- Tighten the mounting bracket.
- Ensure a proper tightness around the burner block with a heat resistant material.

Existing furnace (hot installation)

- Measure the reference position of old block and remove it. Plug the hole by a row of refractory brick (~80mm thickness)

- Preheat the block during 24h ~ 500-600°C to remove all moisture. Block must be covered by alumina wool and installed in front of the opening plugged by brick (support is needed near the opening) or on forehearth.
- Mount the bracket (if not possible after block installation in furnace wall) with respect to their mark.
- Position the block (and its brackets) in front of the furnace opening. Plug the block holes with refractory wool.
- For AZS material (ERMOLD, ZEDMUL, Zircomullite: Permit the block to heat up close to ambient furnace temperature during 30'- 60' while keeping front/back face ΔT<500°C with alumina wool covering it and then insert block in the furnace at a rate of 10 cm per 15' up to place block outlet face in the same plane as the inner furnace wall thanks to reference position.
- For other type of block (high Alumina or Chrome): to avoid thermal shock, push the block (with its brackets if mounted) slowly into the opening, while keeping front/back face ΔT<500°C, at a rate of 5cm per hour for the first 15cm, and 10cm per hour afterwards (see figure below) up to place block outlet face in the same plane as the inner furnace wall thanks to reference position. During this step, keep alumina wool in front of brackets (if mounted) to avoid their overheating.
- Tighten the mounting bracket after removal of support and before complete installation of burner inside the furnace wall.

Note: never use internal hole of the block to lever or displace the block.



3. Preparation of the burner parts

The burner is delivered "Oxygen clean". Before assembling the burner, make sure that all parts have not been contaminated by grease, oil or particulates. If it has been contaminated, all metallic parts of the burner must be thoroughly cleaned one by one in order to eliminate all traces of oil or grease and of

particulates. Use only oxygen compatible products for this operation. In case of a doubt on what product to use and procedure, contact an Air Liquide representative.

4. Installation of the burner body on the block

Install the burner in the block just before firing it.

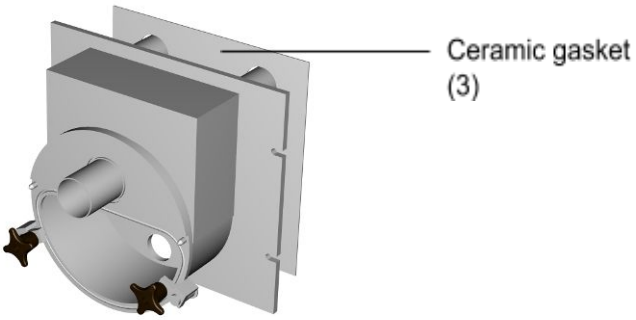


Figure 1

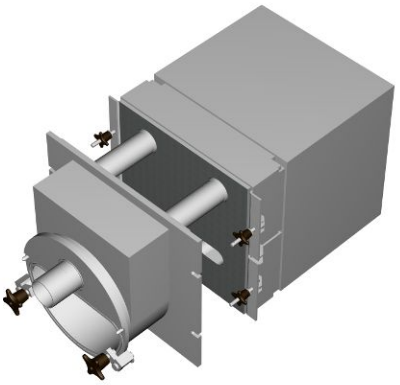


Figure 2

1. Place the square ceramic fiber gasket (3) on the burner body (see Figure 1),
2. Connect the oxygen hose to the burner and open the manual valve: from now on, cooling air must flow through the burner,
3. Remove the alumina wool plugs from the block, and check that the inside of the block is not obstructed by foreign materials (fibrous refractory or glass condensates),
4. Place the burner body in the block (see Figure 2),
5. Place the bracket adapter bolts in the burner body plate slots, and tighten them to compress the ceramic fiber gasket by 50%.

Notes:

The manual oxygen valve must always be opened, except when removing the burner body.

Never use the burner body as a lever to displace the block.

Cooling air must be clean, dry and oil-free

5. Installation of the gas lance

The gas lance (Figure 3) is mounted in the burner body only when everything is ready to fire the burner.

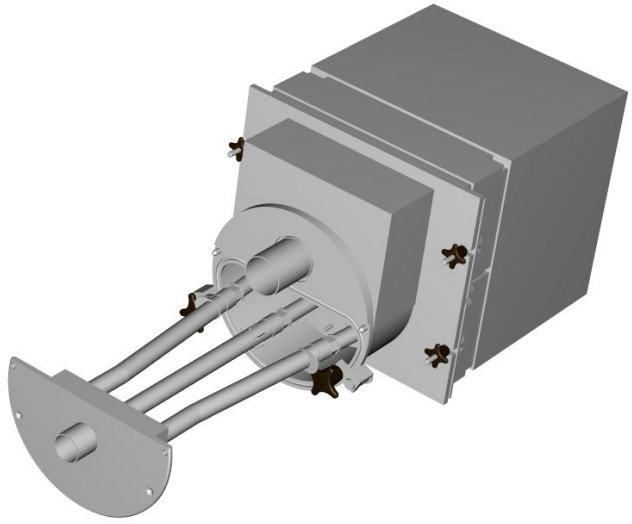


Figure 3

1. Install the flat Viton sheet gasket on the burner body flange,
2. Mount the gas injectors (inner and outer) on the gas lance,

- Use a special grease compatible with oxygen,
- Tightening of the gas injectors must be done by hand (no tools),

3. Check that the gas orifices are not obstructed by foreign material,
4. Connect the gas flexible hose,
5. Check cooling air is flowing through O2 burner body,
6. Insert the gas lance in the burner body (see Figure 3),
7. Tighten the nuts to compress the flat Viton sheet gasket,
8. Open the manual natural gas valve.

In order to avoid overheating of the metallic parts, fire the burner immediately.

WHEN COOLING AIR IS NOT AVAILABLE, THE GAS LANCE MUST BE DISMOUNTED FROM THE BURNERS. IF THE GAS LANCE IS LEFT IN THE BURNER WITHOUT COOLING, SYSTEMATICALLY INSPECT IT AS DAMAGE MAY HAVE OCCURRED TO THE METALLIC PARTS (see maintenance chapter).

F . BURNER MAINTENANCE

It may be necessary to remove a burner for regular maintenance inspections or when the burner will not be used for a long period of time.

1. Inspection of the injectors

1. Turn the burner off,
2. Close the manual natural gas valve,
3. Unfasten the gas lance nuts,
4. Remove the gas lance,
5. Check inside the block is not obstructed by any materials (refractory or glass deposit),
6. Check the inner and outer gas injector tips (deformation, burnt parts),
7. Replace the gas injector tips if necessary (**check that the new gas injectors are free of traces of oil and grease, and clean if necessary**),
8. Reinstall the gas lance as described in section E.5.

During the first month of operation of the burner, inspection of the injectors must be carried out every week. During the second month, the period between inspections can be extended to two weeks. Air Liquide recommends that each gas injector is inspected every month, and every time a burner is left in the furnace without cooling air.

2. Unmounting the burner

When the burner is not going to be used for extended periods of time, the burner should be removed from the burner block.

1. Turn the burner off,
2. Close the manual natural gas valve,
3. Unfasten the gas lance nuts,
4. Remove the gas lance,
5. Unfasten the bracket bolts,
6. Remove the burner body from the burner block,
7. Plug the block orifices with Alumina wool,
8. Disconnect O2 flexible hose from burner body and NG flexible hose from gas lance,
9. Store the burner body and the gas injectors in a clean dry area.

A burner that was previously removed may be re-installed by following the same procedure as described in Chapter E.

Use only new ceramic gaskets for the burner body to block tightness.

All the burner metallic parts must be carefully cleaned for use with pure oxygen.

The inside of the block has to be inspected and cleaned if necessary.

Before attempting burner mounting on a hot furnace, the operator should perform a dry run of the burner assembly in a less hostile environment.

3. Cleaning and inspection of the gaskets

Every time a burner is dismounted, a cleaning of all metallic parts (without flat VITON sheet gasket or O-ring) that are in contact with pure oxygen by a specific cleaner product for oil and grease is mandatory.

The flat VITON sheet gasket on the flange, and the gaskets of the quick connecting components, must be inspected every 3 months.

Every year, all these sealing components must be replaced by new ones.

4. Spare parts

Contact CNPL:

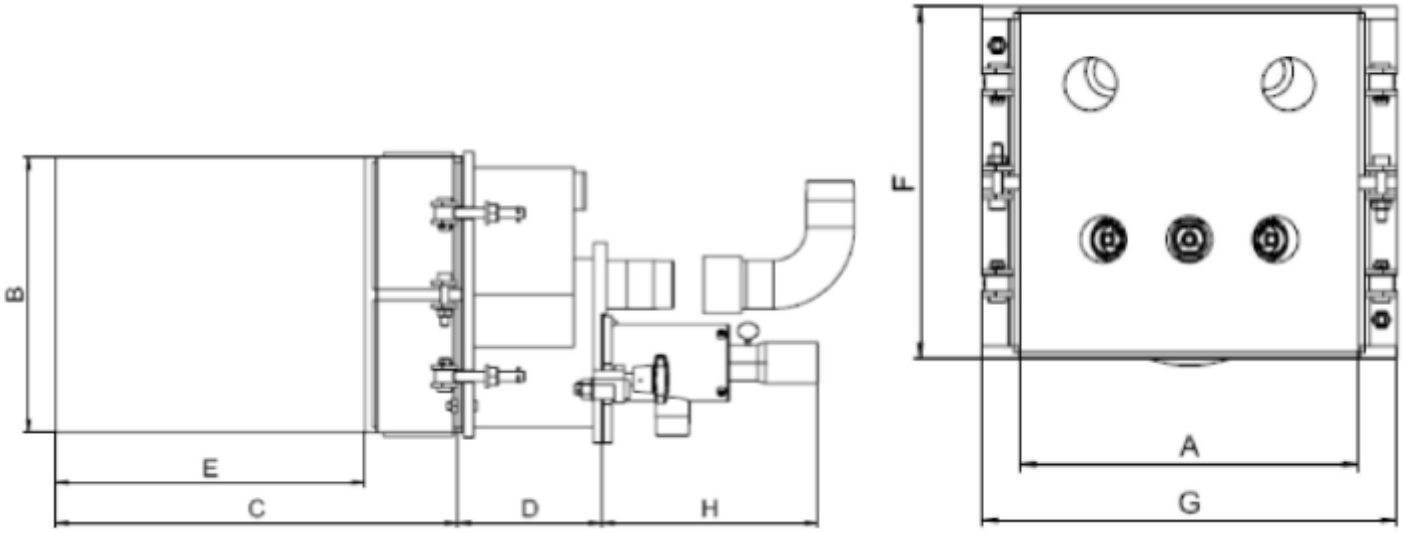
Air Liquide
CombustioN Product Line
1, chemin de la Porte des Loges
78350 Les-Loges-En-Josas - France

E-mail : ww-al-cnpl@airliquide.com

G . APPENDIX

1. Burner dimensions

Model (kW)	Size (mm)								Connections		Weight (kg)	
	A	B	C	D	E	F	G	H	O2	Gas	Block	Total
200	220	220	406.4	114	349,4	230	282	216	M-G 1" BSPT	M-G 1/2" BSPT	50	63
500	220	220		114	349.4	230	282	217	M-G 1"1/2 BSPT	M-G 1" BSPT	50	67
1000	275	275		142	309.4	285	337	215			76	98
2000	330	330		139	306,4	340	392	215	M-G 2" BSPT	M-G 1"1/4 BSPT	103	128



2. Capacity ranges and pressure drop

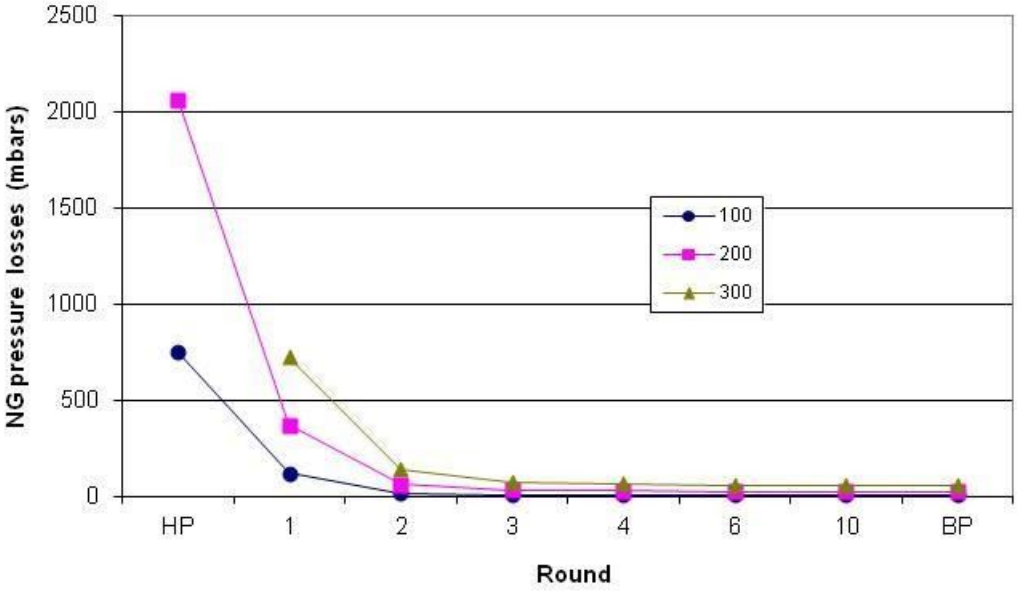
- Capacity ranges of the ALGLASS FC VM burner:

Model	Maximum capacity (kW)	Nominal capacity (kW)	Minimum capacity (kW)
ALGLASS FC VM 200	300	200	50
ALGLASS FC VM 500	900	500	150
ALGLASS FC VM 1000	1800	1000	300
ALGLASS FC VM 2000	3600	2000	600

- Pressure drop of the ALGLASS FC VM burner:

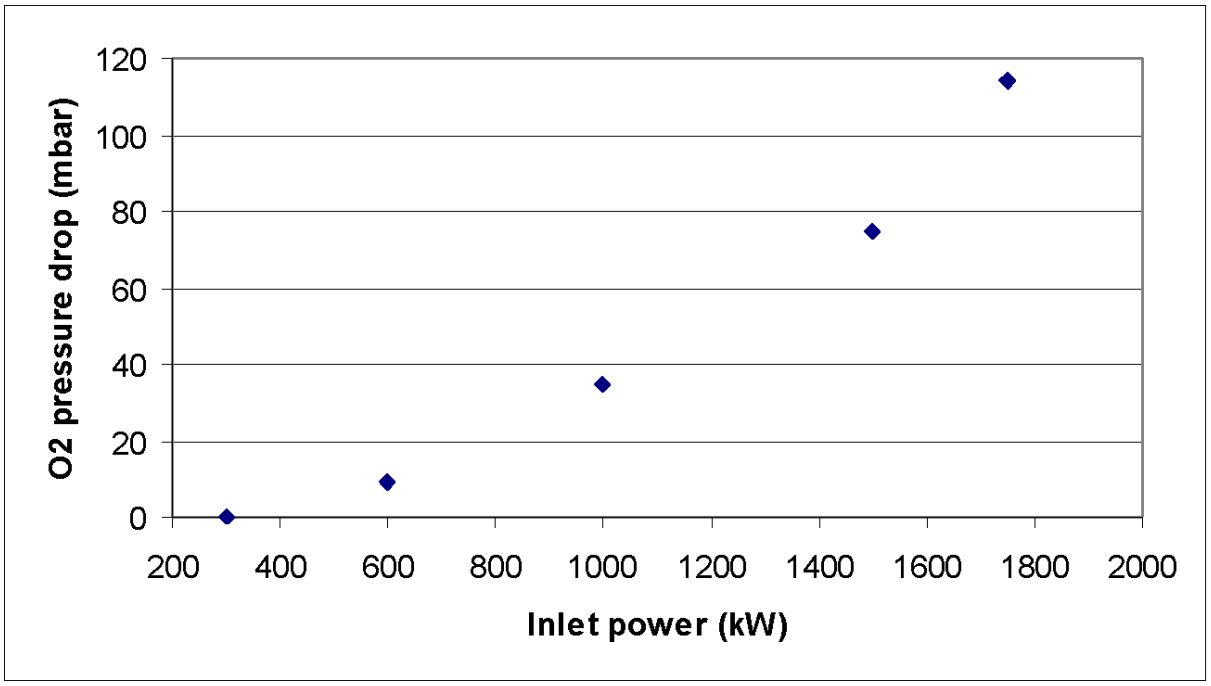
The ALGLASS FC VM burner requires low oxygen and fuel inlet pressures. The exact value of the pressure drop through the burner can be determined from the following graphics which show natural gas and oxygen pressure drop measurements depending on the power for the ALGLASS FC VM 200 & 1000 kW burner. Actually, the pressure drop for natural gas is given depending on the valve rotation (or opening); the more the valve is opened, the more the pressure drop decreases.

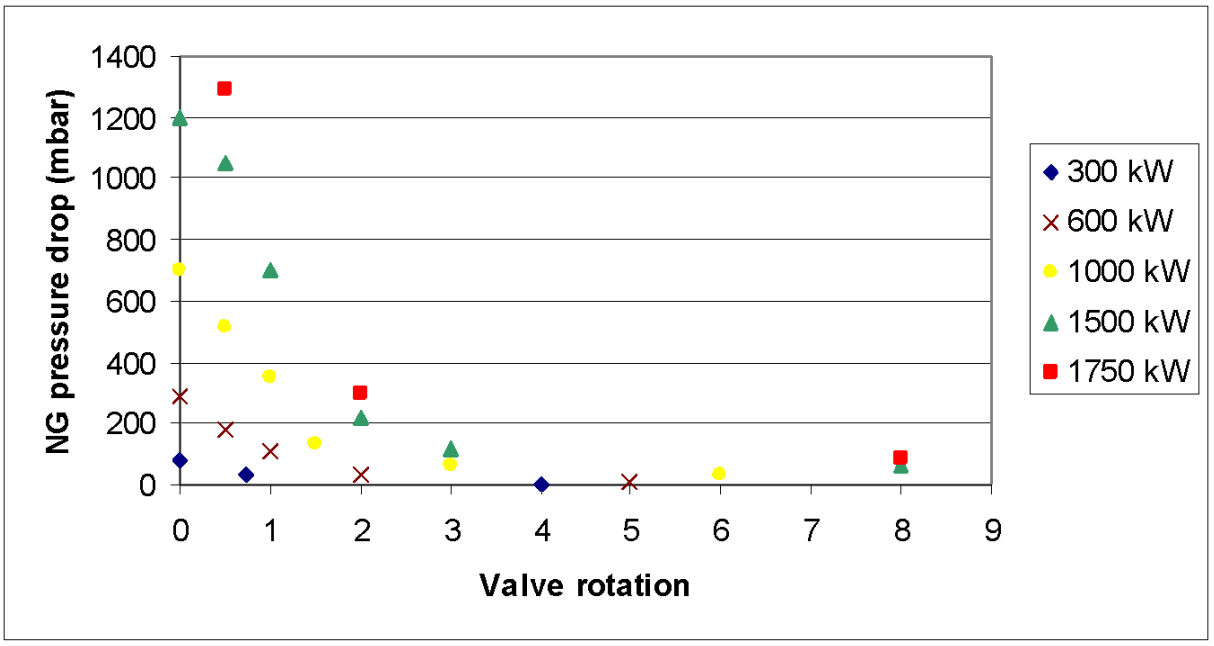
Natural gas pressure drop for the ALGLASS FC VM 200 kW:



Oxygen and Natural gas pressure drop for the ALGLASS FC VM 1000 kW:

Note: pressure drop values for the ALGLASS FC VM 500 kW burner are very similar to those of the ALGLASS FC VM 1000 kW burner.





Natural gas pressure drop of 50 mbar (controlled by tuning valve) for ALGLASS FC VM 2000 kW and depending on power:

NG pressure drop (mbar)	Valve rotation	NG Flow (Nm3/h)	Power rate (kW)
50	5	189	2000
50	2.5	142	1500
50	1	94	1000
50	0	83	880

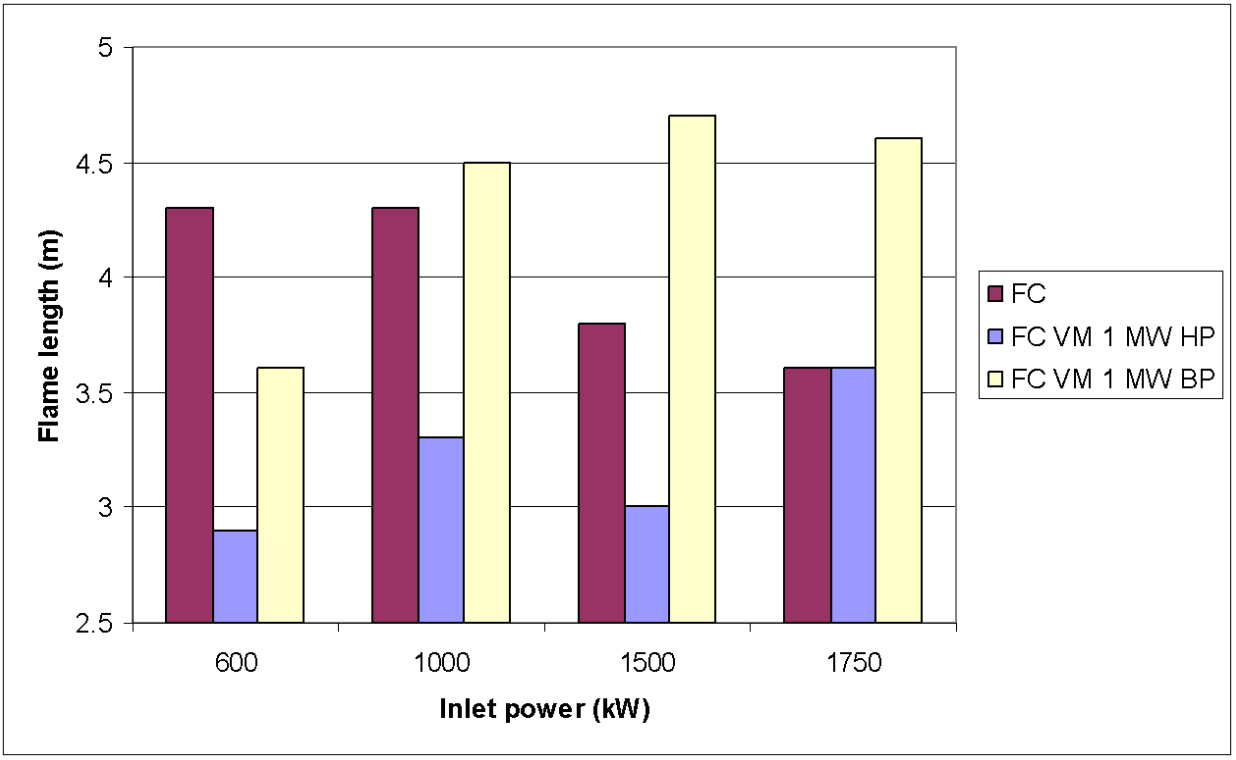
3. *Flame length and heat transfer*

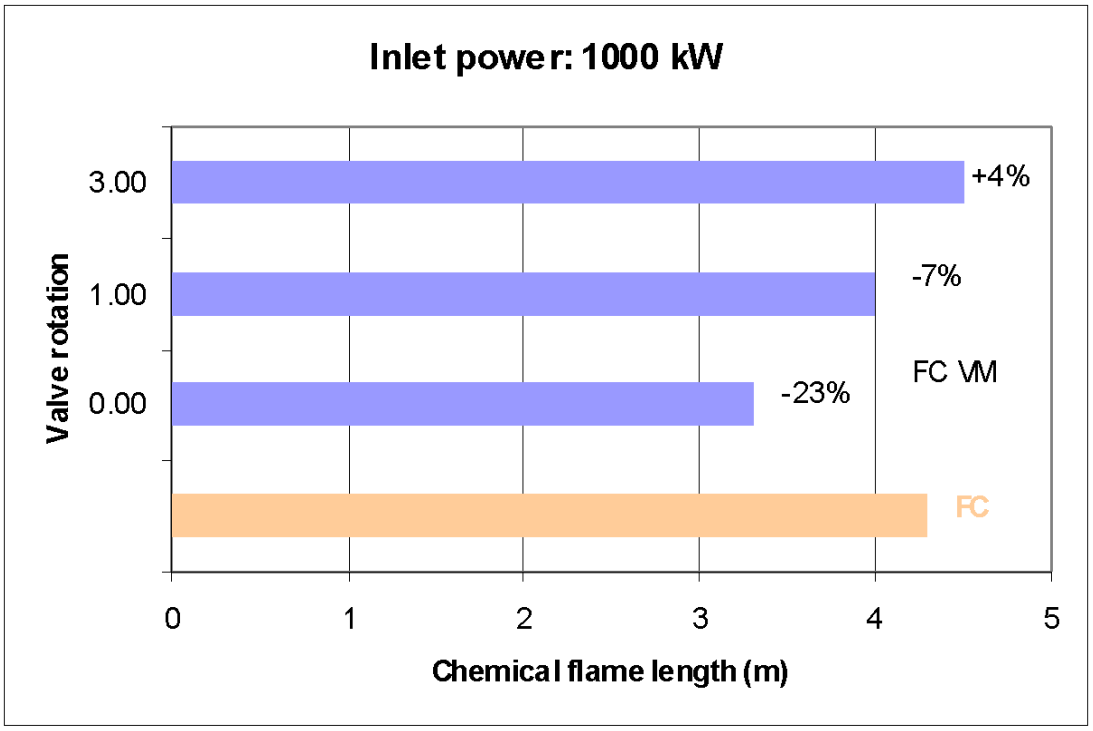
- Flame length and heat transfer of the ALGLASS FC VM burner:

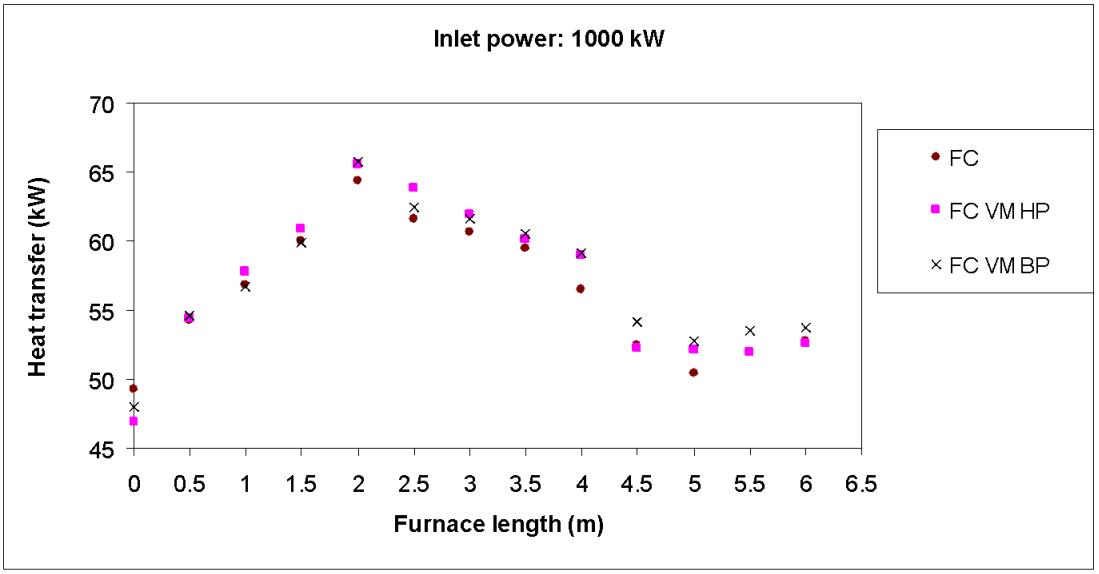
The ALGLASS FC burner produces a highly luminous flame up to three times wider than conventional oxy-fuel burners (pipe-in-pipe configuration) and allows an effective energy transfer.

In addition, the ALGLASS FC VM technology allows a tuning parameter for the flame length and therefore for the heat transfer.
By closing the valve of the fuel lance, the visible flame length decreases about 10%: the more the said valve is closed, the more the gas passes through the NG inner injection (or HP) part only and therefore the more the NG momentum increases.
On the other hand, the more the said valve is opened, the more the natural gas goes through both inner (HP) and outer (BP) channels, and therefore the more the flame length increases. Comparably, it also permits to tune the heat transfer, either it is preferable to transfer more heat close to the burner location or it is preferable to transfer homogeneously the heat regarding a long distance when the flame shape is larger.

The following graphics show measurements performed in ALICE furnace at the Innovation Campus Paris for the ALGLASS FC VM 1000 burner compared to the ALGLASS FC 1000 burner.
HP means that the ALGLASS FC VM burner is operated with no (or zero) valve rotation on the fuel lance.
BP means that the ALGLASS FC VM burner is operated at the maximal valve rotation beyond which increasing the valve rotation does not change the flame characteristics any more.


5
4.5
4
3.5
3
2.5
Flame length (m)
600
1000
1500
1750
Inlet power (kW)
FC
FC VM 1 MW HP
FC VM 1 MW BP


Inlet power: 1000 kW
3.00
1.00
0.00
Valve rotation
+4%
-7%
-23%
FC VM
FC
0
1
2
3
4
5
Chemical flame length (m)



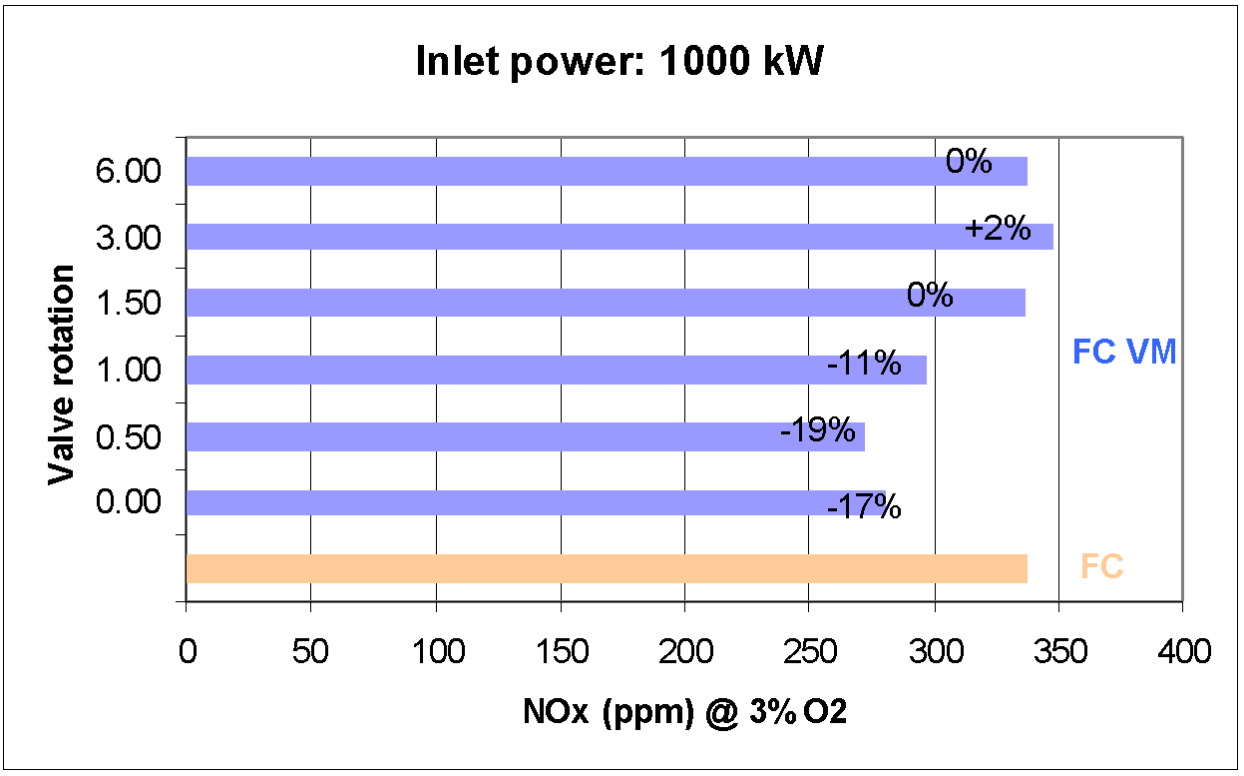
Flame length for ALGLASS FC VM 2000 kW:

Power rate (kW)	Length (m)
2000	4.6
1500	4.5
1000	4.2
880	3.1

4. Nox emissions

- Nox emissions of the ALGLASS FC VM burner

The ALGLASS FC VM burner produces low NOx emissions. Actually, the ALGLASS FC VM burner allows decreasing NOx emissions in comparison with the ALGLASS FC burner.
See the following graphic where NOx emissions are presented for both ALGLASS FC 1000 kW and ALGLASS FC VM 1000 kW burners, considering 3% of O2 in exhaust gases, when these burners are operated at 1000 kW in the ALICE pilot furnace at the Innovation Campus Paris.
It can be noticed that the maximal decrease (about 17-19%) is obtained when natural gas goes mainly / only through the inner injection.



5. General instructions for proper working conditions

- General instructions for proper working conditions of the ALGLASS FC VM burner
  1. The ALGLASS FC VM burner requires control over the fuel and oxygen, so we recommend the installation of a calibrated flow meter on the fuel and oxygen lines for determining accurate volumetric or mass flow rates.
  2. During combustion, on the one hand the burner body and the top part of burner block are cooled by the oxygen flow, and on the other hand the natural gas lance and its injectors are cooled by the natural gas flow. However when combustion is not taking place, all parts of the burner, and notably the fuel gas lance, are heated and can be destroyed by high furnace temperatures. In this case, a cooling air flow should be established inside oxygen line and a cooling nitrogen flow should be established inside natural gas line. It is very important to supply the cooling nitrogen flow in both BP channel and HP channel. And it is recommended to supply a cooling flow rate that is preferably equivalent to 30% of reactants nominal flow rate.

3. When cooling nitrogen is not available, the fuel lance must be dismounted from the burner. If the fuel lance is left in the burner without any cooling, systematically inspect it as damage to the metallic parts may have occurred. However the fuel lance can stay in a hot furnace for 15 minutes without any cooling.
4. Quick-coupling systems for the oxygen and fuel will facilitate disassembly and installation.
5. Quick-coupling systems also make possible to limit the time for which the burner parts, notably the fuel gas lance, are subjected to furnace temperatures without cooling flow.
6. Piping needs to be supported in order to avoid stresses on the burner body which could lead to cracking of the burner block.
7. Flexible hoses are advised for the burner supply. Flexible hoses can prevent the burner from damage due to stresses / expansion of the piping.
8. The burner block made of AZS rebounded material (Al_2O_3 + ZrO_2 + SiO_2) is generally suitable for most applications. However, it is necessary to ensure that this material is compatible with the customer process.
9. Viewing the flame through observation windows, such as peeping holes, makes burner start-up and adjustments easier.
10. Oxygen and fuel supply piping must be rated for the pressure and flow rate requirements of the burner operating at maximum capacity. Avoid long distances and turns in the piping as they increase the pressure drop.

6. Gas specifications and how to operate the fuel gas lance

- Gas specifications for the ALGLASS FC VM burner

MODEL	ALGLASS FC VM 200	ALGLASS FC VM 500	ALGLASS FC VM 1000	ALGLASS FC VM 2000
Min. oxygen temperature at burner inlet	10 °C			
Max. oxygen temperature at burner inlet	40 °C			
Min. Natural gas temperature at burner inlet	10 °C			
Max. Natural gas temperature at burner inlet	40 °C			
Oxygen supply pressure at burner inlet	0 to 20 mbar g.	20 to 120 mbar g.		
	Oxygen pressure drop through the burner depending on the power adjustment			
Natural gas supply pressure at burner inlet	50 to 2000 mbar g.	50 to 1300 mbar g		
	Natural gas pressure drop through the burner depending on the power adjustment and valve rotation			
Cooling air flow rate	20 Nm3/h	30 Nm3/h	60 Nm3/h	120 Nm3/h
Cooling nitrogen flow rate	10 Nm3/h	15 Nm3/h	30 Nm3/h	60 Nm3/h

- How to operate the fuel gas lance of the ALGLASS FC VM burner

<u>This paragraph describes how to operate the fuel gas lance</u>:

1. Start with tuning valve completely closed (completely on the right) – this means all the fuel gas is sent through the inner injection (or HP).
2. Keep this valve closed as long as the power is low and the flame shape fits with the requirement.
3. When power is increased or when more lazy flame is needed turn the tuning valve to the left (open more and more the outer injection (or BP)).
4. Stop to turn this valve when flame shape is acceptable.