SUSTAINABLE TECHNOLOGIES FOR HYDROGEN

Padova, the 07th of May 2026

Contents of the Lecture

- Presentation of Polidoro company
- Preface and context: H_2 in boilers
- Review of combustion basics, burners, boilers
- H_2 properties as a fuel, compared with CH_4
- Polidoro research facilities
- Burners for CH_4-H_2 blends
- Burners for premixed boilers 100% H_2
- Practical examples and case studies
- Questions

Polidoro company

Polidoro Group

In Polidoro, we believe in a sustainable future through the development of innovative solutions and customized technologies for **the heating market**, offering **efficiency**, **comfort**, **compliance with regulations** and **low emissions** into the environment.

POLIDORO

Gas Burners

Brazed Plate Heat Exchangers

Facts and figures

53
MLN € OF AVERAGE TURNOVER

40.000
TOTAL SQM OF OUR PRODUCTION PLANTS

300
EMPLOYEES WORLDWIDE

180
PATENT APPLICATIONS FROM 70S

5,5
MLN OF PRODUCTS SOLD EVERY YEAR

550
CUSTOMERS AROUND THE WORLD

Group asset and skills

Italy HQ - Schio

R&D – Research Center
Direct production of **gas burners** for
Direct production of **brazed plate heat exchangers**
Direct production of **metal fiber rolls**

Manisa - Turkiye

Direct production of burners for:

- Condensing boiler and condensing GWH
- Not condensing boiler WHB
- Low NOx IGWH

Changzhou - China

Direct production of burners for:

- Not condensing boiler WHB
- Low NOx IGWH

Salaspils - Latvia

Direct production of BPHE:

- Single-phase
- Two-phases

Houston - USA

Sales office

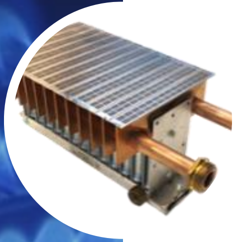
Solutions for Atmospheric (non condensing)

80 ANNIVERSARY 1945-2025

POLIDORO

LNA – water cooled Low NOx

Heat Input	2,2 kW each element
Modulation	1:3
NOx	< 56 kW/h
Elements	From 5 to 18
Water-cooled	
Modular structure	



BNOx

Heat Input	2,2 kW each element
Modulation	Up to 45%
NOx	< 56 kW/h
Elements	From 4 to 20
Water-cooled	
Modular structure	

Ultra Low NOx

Power Range	From 30 to 50 kBTU
Combustion chamber Ø	From 14 to 18 inches
NOx	< 36 mg/kWh

NP – Dry low NOx burner

Heat Input	From 2 to 2,3 kW each element
Modulation	1:3
NOx	< 150 kW/h
Elements	From 5 to 20
Std blade pitch	17,5 – 19 – 20,5 mm

Tubular burners

Diameters	40 – 51 – 60 mm
Modulation	1:2 (1:3 if fan assisted)
NOx	< 150 kW/h
Max length	From 680 to 980 mm

Solutions for condensing

Stainless Steel premix burners

Heat Input	Up to 130 kW
Modulation	1:20
NOx	< 56 mg/kWh
Diameters	50-60-63-70-80-100 mm
Max length	600 mm (350 for Ø 50mm)

Complete burner door

Boilers	
CH	From 21 to 45 kW
DHW	From 24 to 48 kW
Water heaters	
From 24 to 53 kW	

Cylindrical metal fiber burners

Heat Input	Over 100 kW
Modulation	1:20
NOx	< 56 mg/kWh
Diameters	from 40 to 480 mm
Max length	from 200 to 2.000 mm

Flat metal fiber burners

Heat Input	Up to 220 kW
Modulation	1:20
NOx	< 56 mg/kWh

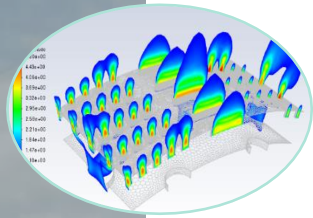
HM Mixer

Models	
HM60	From 15 to 55 kW
HM150	From 60 to 150 Kw
HM500	From 150 to 530 kW

Research Center Facilities

Test Rooms

Also equipped for 100% Hydrogen tests



CFD/FEM

Life test Room

20 test stations and 6 free air – dry chamber stations,

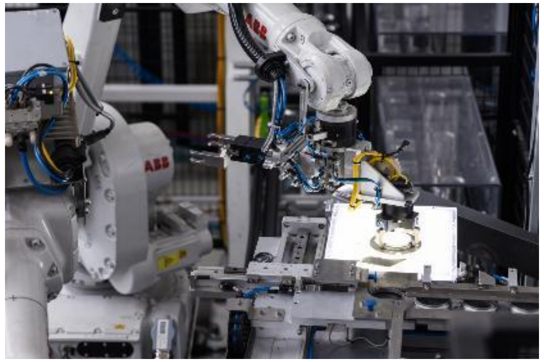
Hemianechoic Room

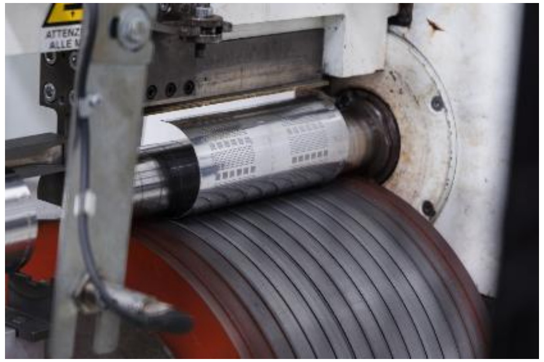
Class 1 - room for acoustic tests and homologation

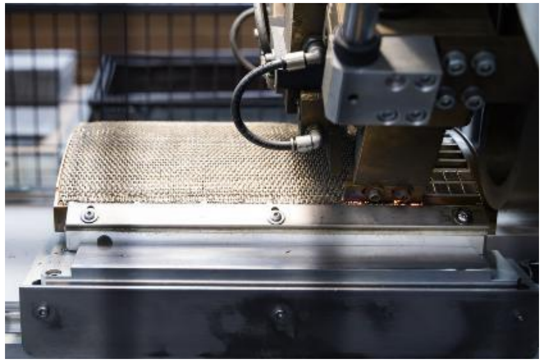
Production technologies

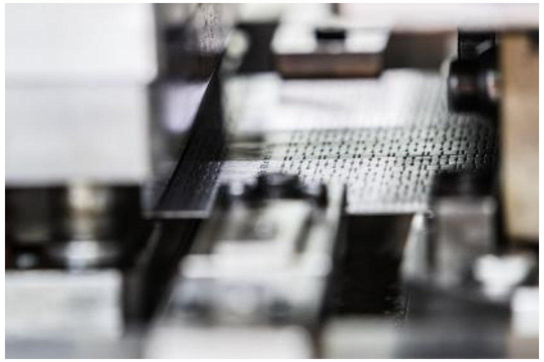
Large scale production of gas burners involves several production technologies: **perforation**, **molding**, **welding**, **brazing**, **painting**, **washing** **bending**, **handling**, **process automation**, **marking**, **light carpentry** and **assembly**.

Our experience in large scale production of gas burners and the availability of different production technologies, allow us to develop and offer high quality gas burners compliant with the international directives, and other **complex metal parts**.









Hydrogen in boilers – Context

European Green Deal

European Commission

“The EU will **reduce its net greenhouse gas emissions by at least 55% by 2030**, compared to 1990 levels, as agreed in the EU Climate Law”

Green Deal → REPowerEU

July 2021

The EU will commit in the "Green Deal"

→

February 2022

Russia-Ukraine war

→

May 2022

The EU enforces the "Green Deal" propositions with "REPowerEU"

RePowerEU

ACCELERATING ENERGY EFFICIENCY THROUGH MID- TO LONG-TERM MEASURES

In July 2021, the Commission proposed an increase of the EU energy efficiency target of 9% by 2030, as part of the ‘Fit for 55’ package. **It is now necessary to go even further.**

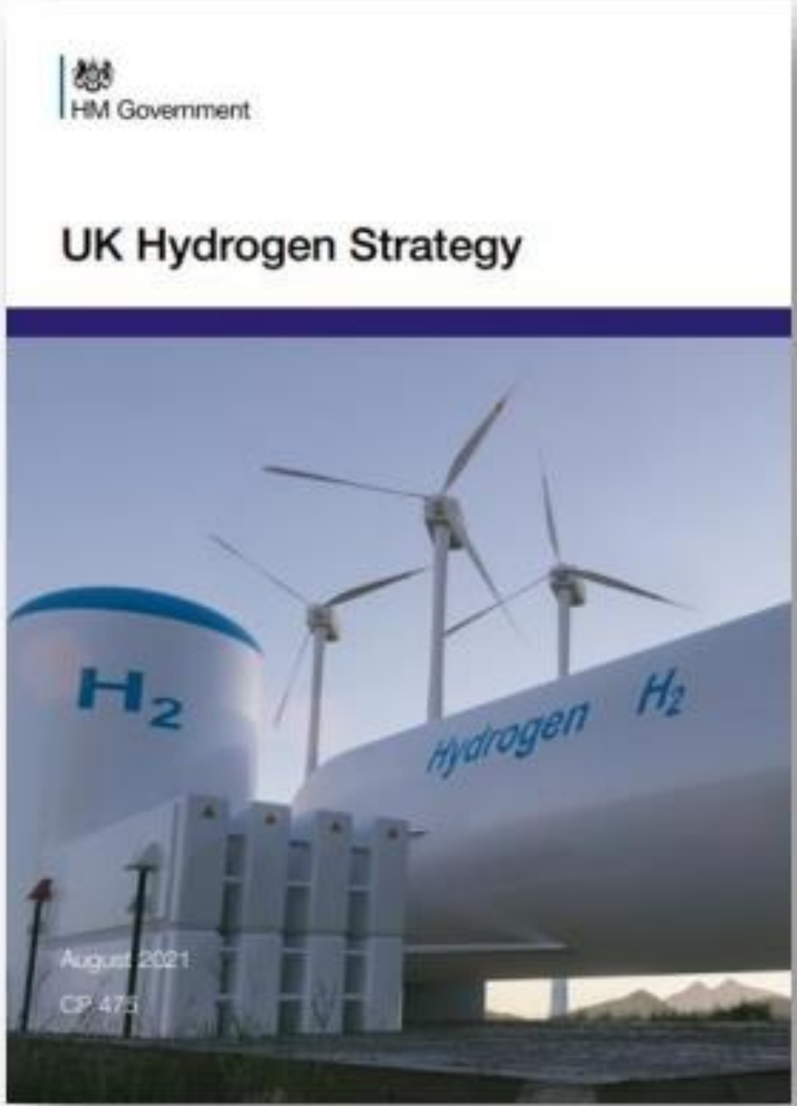
EU energy efficiency target by 2030

9% → 13%

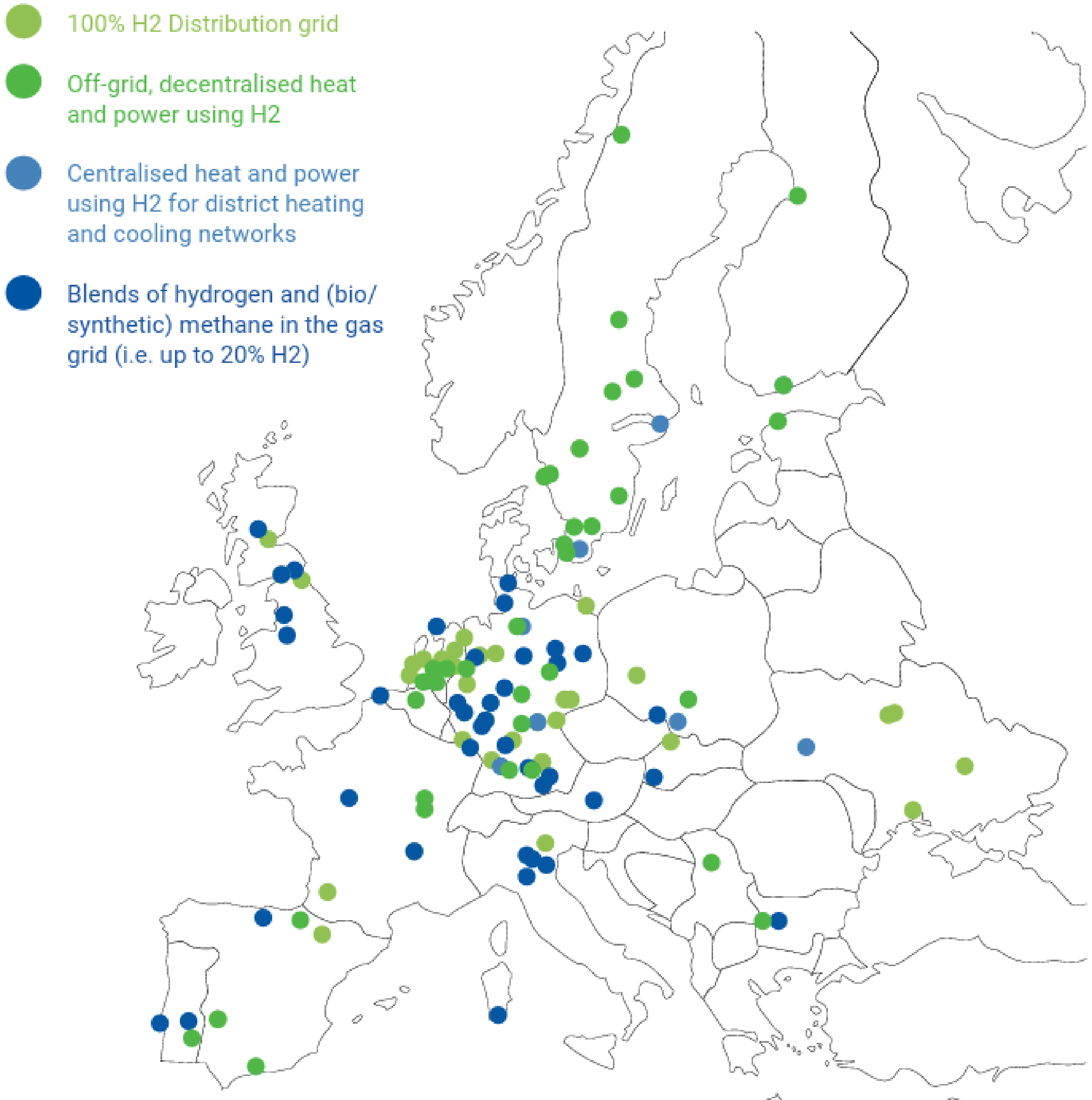
In addition, the Commission invites the Parliament and Member States to consider **other improvements to the Fit for 55 package** that they are currently negotiating:

- Extend **buildings Minimum Energy Performance Standards**
- Strengthen **national energy requirements of new buildings**
- Tighten **national heating system requirements** for existing buildings
- Introduce **national bans for boilers based on fossil fuels** in existing and new buildings
- Advance the end of Member States subsidies for fossil fuel-based boilers from 2027 to 2025

UK Hydrogen Strategy



H2 pilot projects in EU



Pilot projects all around Europe, where hydrogen is being used for heating in different types of buildings (*)

Hydrogen blending and pure hydrogen
Where are we?

As of 2024, several European countries are experimenting with low-level hydrogen blending in their natural gas grids. In the United Kingdom, the 'HyDeploy' project has demonstrated that blending 20% hydrogen into the natural gas grid "*does not interact negatively with existing materials used within infrastructure like network pipes or in homes or businesses such as boilers, hobs, cookers, or meters.*"[5]
In Germany, in the 'Wasserstoff-Insel Öhringen' project, the grid operator Netze BW has successfully carried out a test to inject up to 30% hydrogen in the natural gas network in real operation, proving that the infrastructure is technically capable of distributing hydrogen.

When it comes to pure hydrogen, the H21 initiative in the UK seeks to demonstrate the feasibility of using it in urban gas distribution networks. The H21 Leeds City Gate is a pioneering project in the UK aimed at converting the entire natural gas network of Leeds to 100% hydrogen. It provides evidence that converting a gas network from natural gas to pure hydrogen is technically possible. The GET H2 Nukleus project taking place in North Rhine-Westphalia (Germany) successfully converted approximately 130 kilometers of existing natural gas pipelines to transport pure hydrogen.

(*) Report on hydrogen-readiness of gaseous fuels distribution infrastructure and heating technologies in Europe, April 2025

Pilot Projects

"Over the 2020s and early 2030s, **our aim is to move to only installing low carbon heat systems that are compatible with our net zero target**...."

"decarbonize heat in buildings ..."

H21 – Leeds

H100 – Fife - Scotland

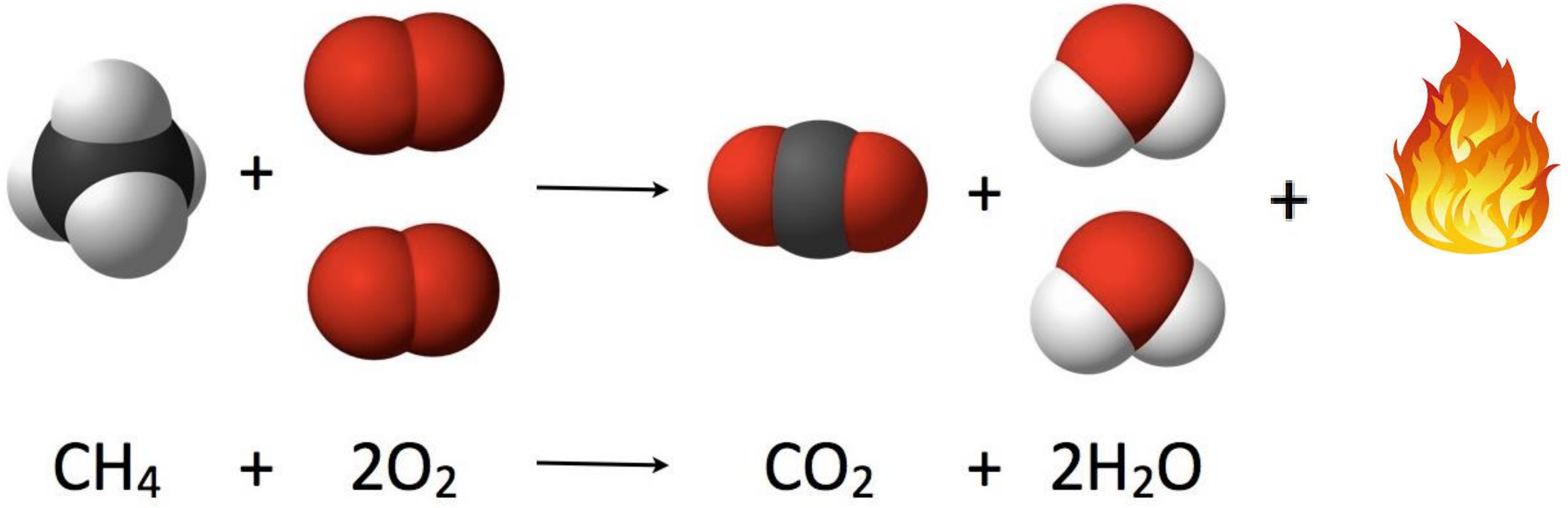
Auf Temperatur mit Wasserstoff: Eine der neuen 100%-H2-Brennwertthermen geht in Hohenwart Betrieb. Foto: Jost Listemann/Zukunft Gas

Pilot projects need commitment of Governments, and are a significant trigger for devices and component manufacturers.

Combustion basics

Combustion basics - Reaction

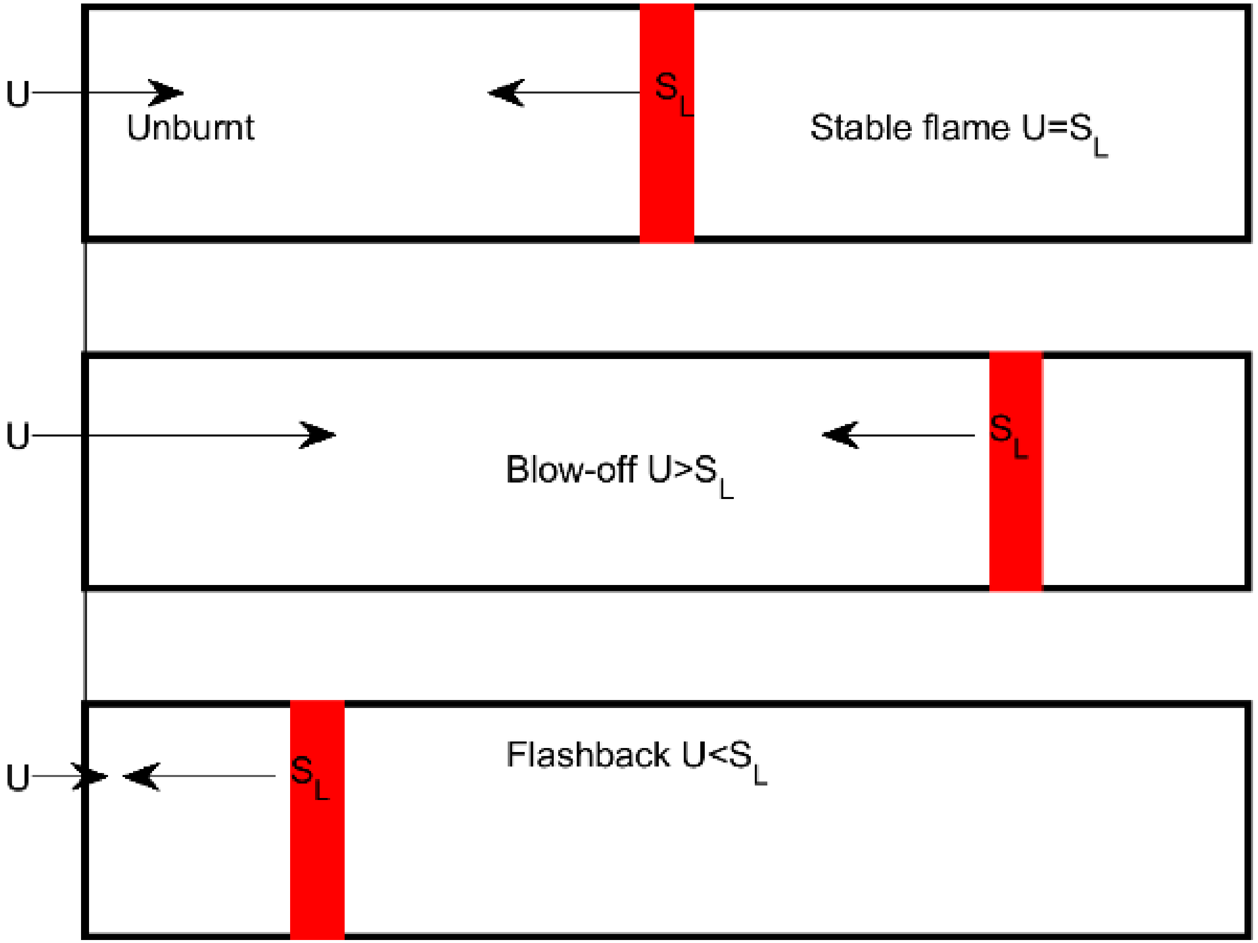
Combustion is a chemical reaction between which transfors moleculas into other, releasing energy (heat and light), recognized as a flame.



$$CH_4 + 2O_2 + 7.52N_2 \rightarrow CO_2 + 2H_2O + 7.52N_2$$

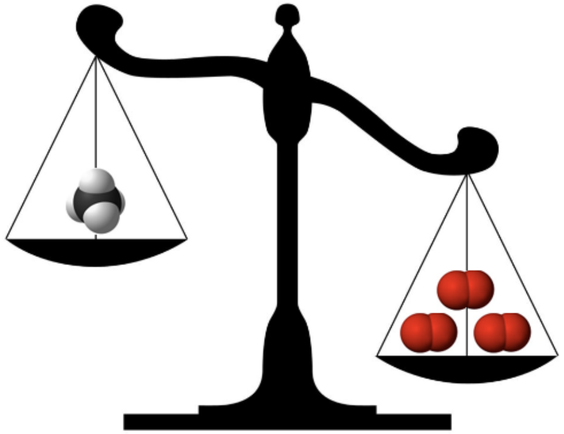
Flame stabilization

A premixed flame stabilizes when there is a kinematic balance between flow and flame velocity.



Combustion basics – LAMBDA

$$\lambda = \frac{Actual\ \ Air\ Quantity}{Stoichiometric\ \ Air\ Quantity}$$



Sometimes f (inverse of λ) or e (excess air) are used.

$$\phi = \frac{1}{\lambda}$$

$$e = \lambda - 1$$

Combustion basics – Emissions

In methane combustion, there are 3 main kinds of pollutants:

CO_2

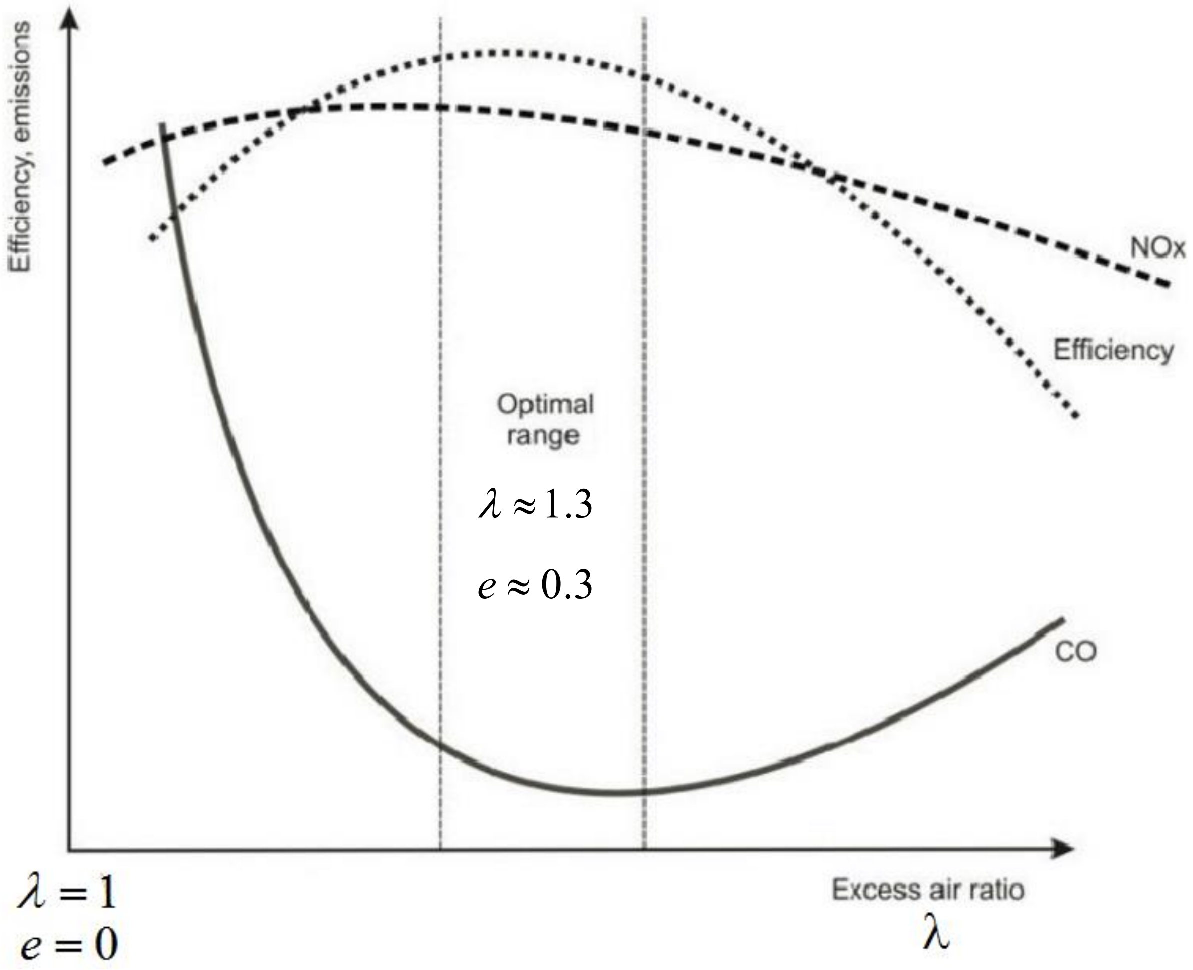
CO_2 is a unavoidable pollutant: it is part of the basic combustion reaction.

CO **NOx**

Unwanted pollutants.
To be minimized.

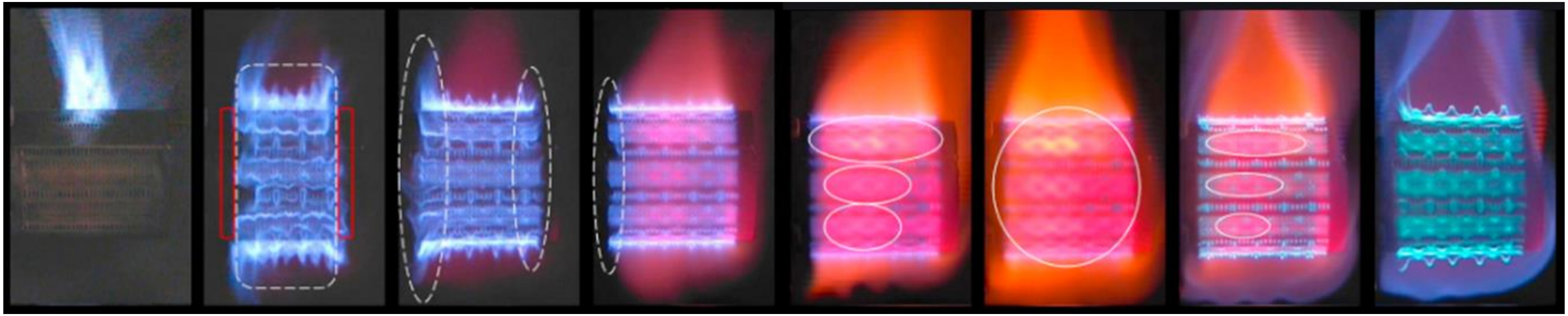
Combustion basics – Effect of LAMBDA

Considering that we want the best possible efficiency with the lower possible emissions, it is clear that choice of lambda is a compromise.



Combustion basics – LAMBDA

It has a big influence on the flame, on emissions, ...



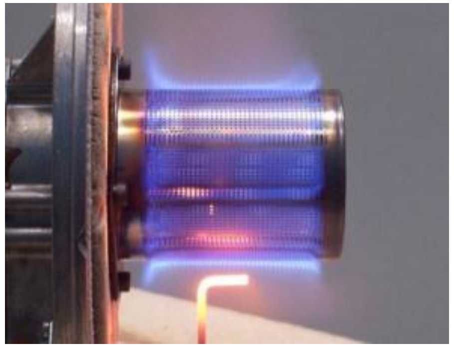
High l → *Low l*

... and on flash back

Boilers and burners

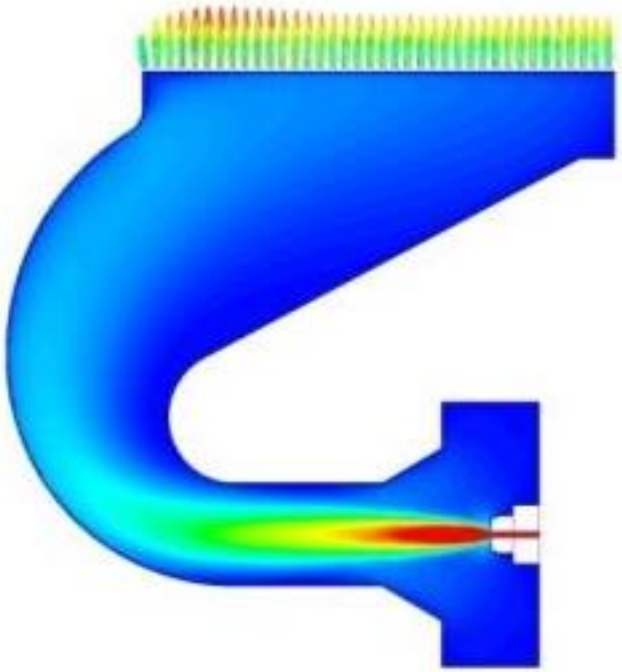
Combustion principles – Types of burner

NON - PREMIXED	PARTIALLY PREMIXED	FULLY PREMIXED
Pure fuel flows from the burner orifices through the air. Diffusion phenomena allows a non-premixed flame to burn.	Fuel and air enter separately into the burner. A fuel rich mixture comes out from the combustor and is burned near its surface with secondary air.	An air/fuel mixture into the flamability limits flows through the burner, on the surface of which the combustion takes place without any additional mixing with air



Types of burners - Partially premixed burners

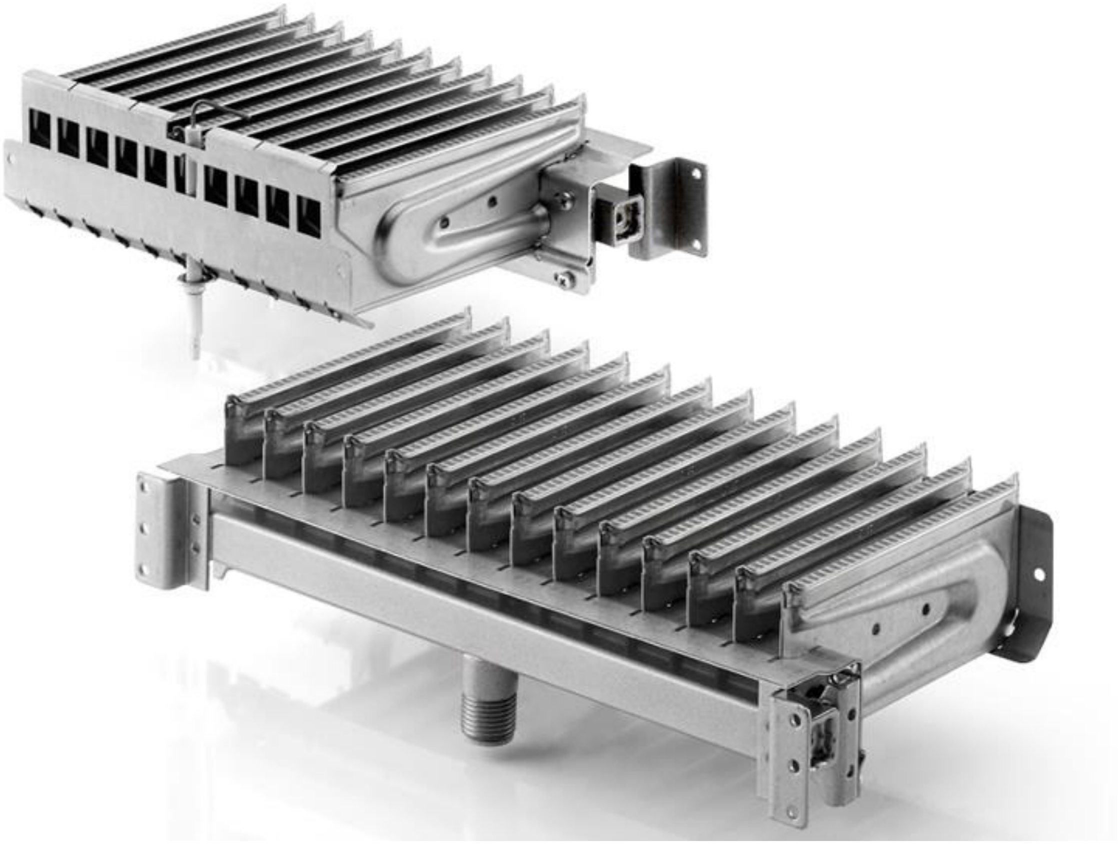
Fuel and air enter separately into the burner. A fuel rich mixture comes out from the combustor and is burned near its surface with secondary air.



The combustion air comes to the flame from different points: there is a primary air (which creates a low lambda mixture) and then a second flow of air (secondary air) completes the combustion.

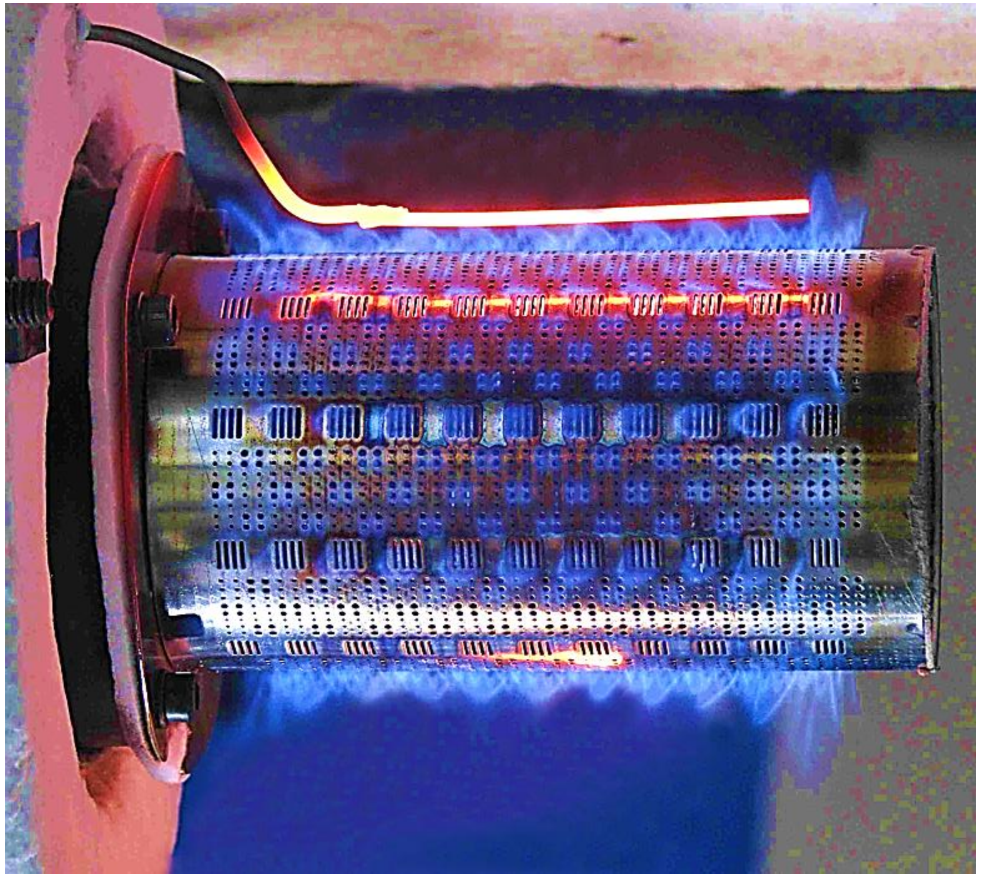
Types of burners – Atmospheric burners - NP

NP burners is the base product for atmospheric burners. It is modular and the gas type is set by means of nozzle of different diameters.



Types of burners - Fully premixed burners

An air/gas mixture, with suitable value of lambda (>1), flows through the burner, on the surface of which the **combustion takes place without additional air.**



Types of burners - Fully premixed burners

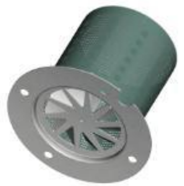
STEEL BURNERS

FIBER BURNERS

Boilers and performances

Advantages of premix:

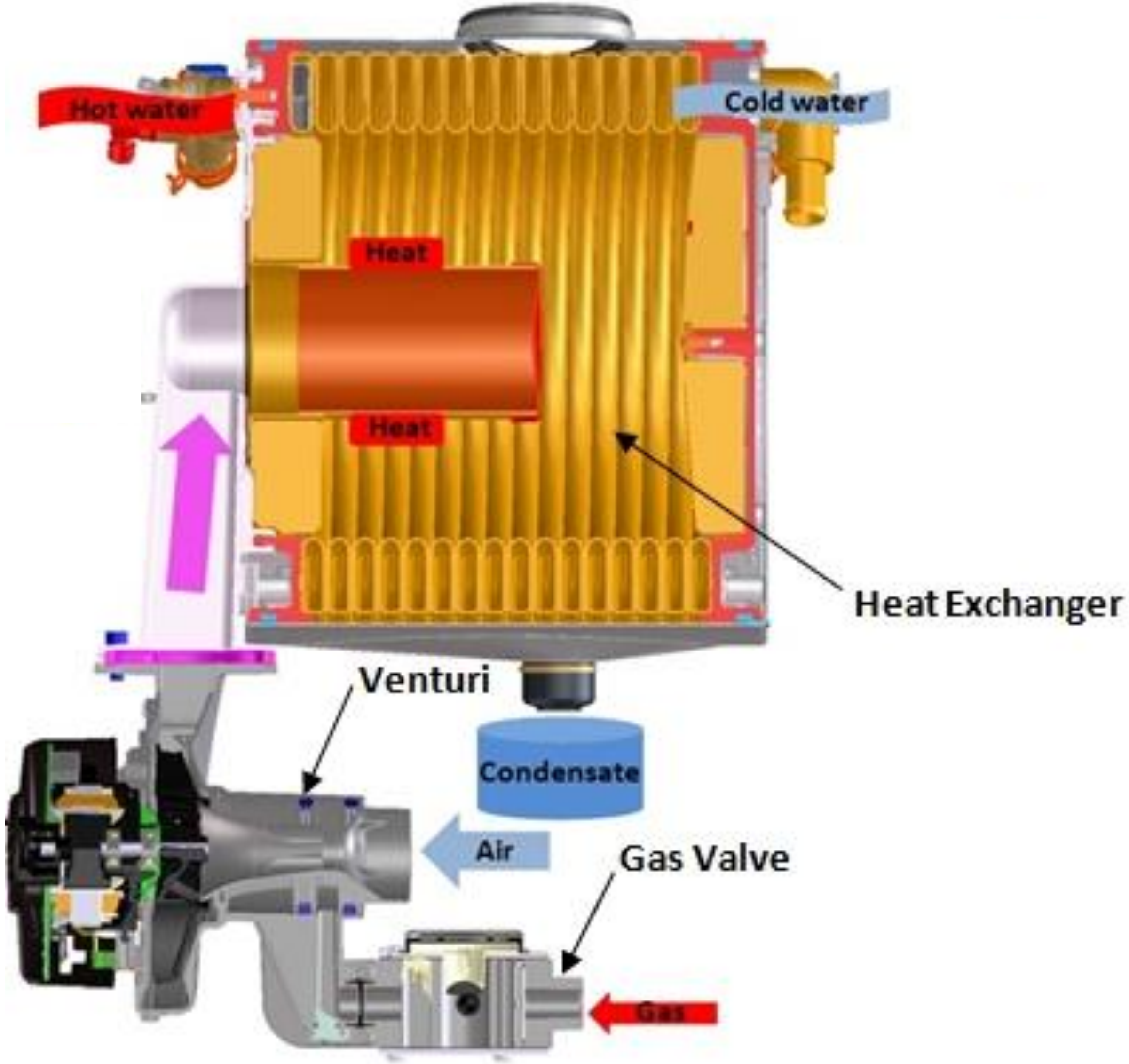
- *Higher energy efficiency*
- *Lower emissions*
- *Compactness*
- *Higher modulation range*

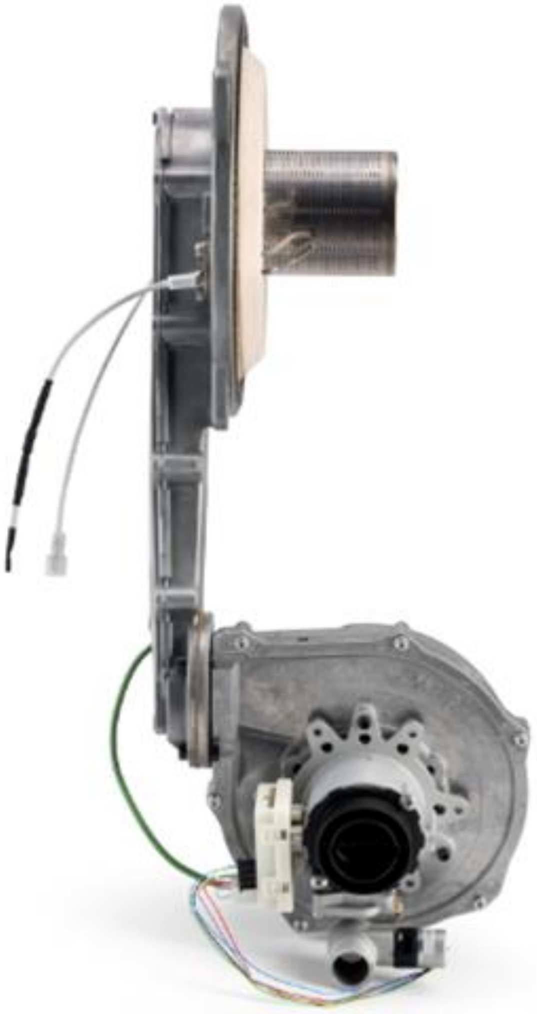


	Conventional / standard boiler	Condensing boiler
Annual efficiency on GCV [%]	62-74%	84-91%
CO max level [ppm]	200-300 ppm	100-150 ppm
NOx max level [ppm]	110-150 ppm	20-45 ppm
Max Modulation range TDR	1:4	1:10 (or more)

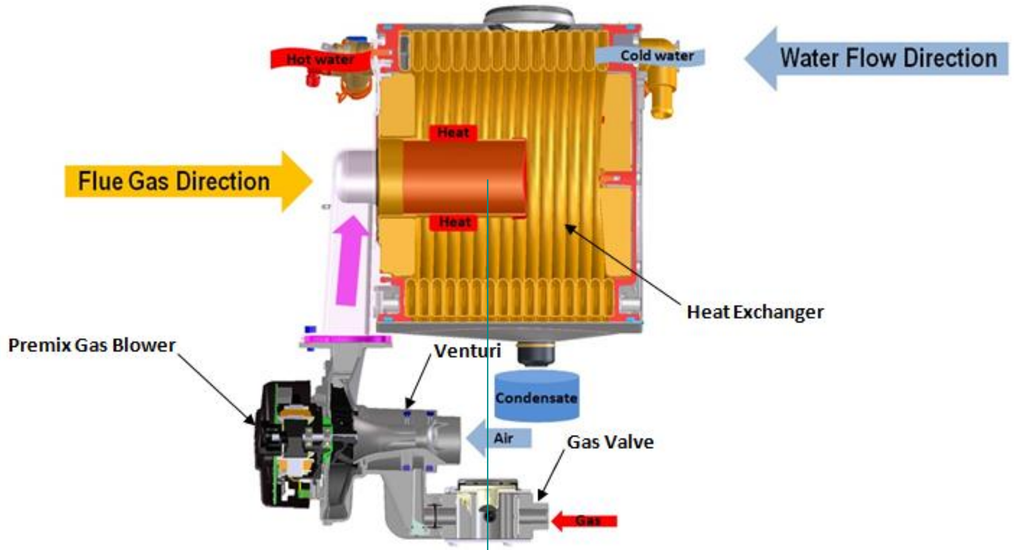
Source for efficiency and Nox: Eco-design Boilers - task 4 - Technical Analysis, VHK for European Commission

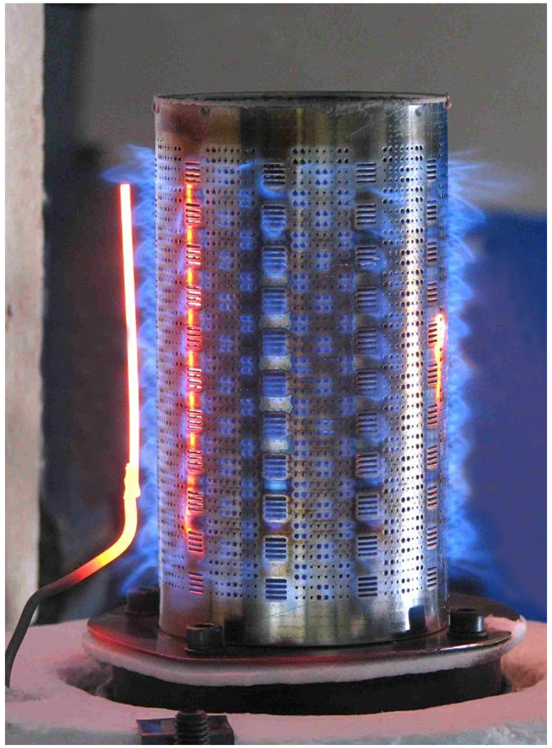
Premix boiler: components





The Burner





The burner is the component where the combustion reactions happen.

Turn-down (or modulation) rate

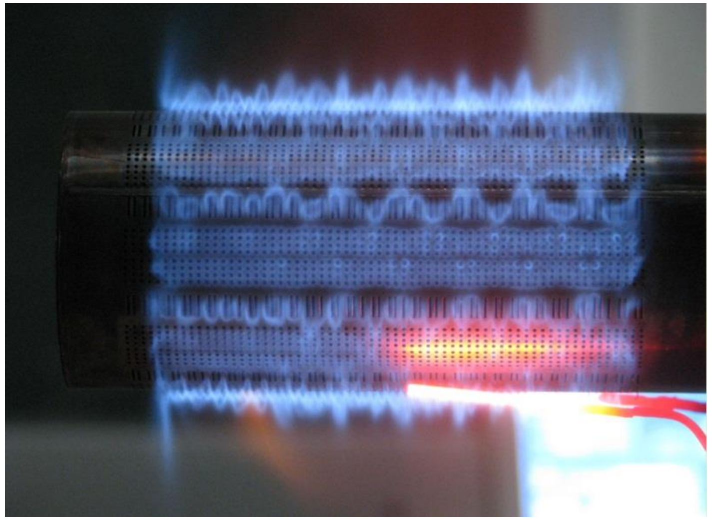
TDR is the ratio between the Maximum and Minimum power:

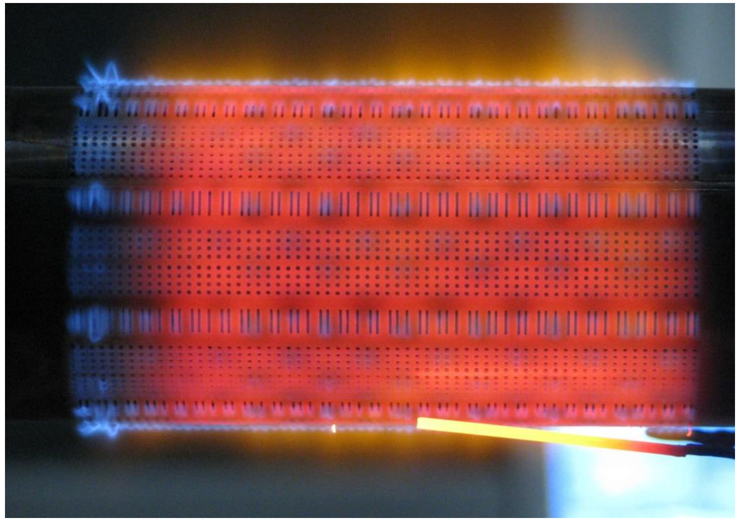
$$TDR = \frac{\text{Qmax}}{\text{Qmin}}$$

For premix boilers, a very common value for TDR is about 5 to 10. A high TDR is useful: for example, in well insulated buildings, where the heating load is very low (e.g. 3 kW) while the DHW production requires the max power (e.g. 30 kW).

Boiler functionality – TDR

But, from the point of view of the burner, this is a stressing condition. Indeed, a burner working at minimum power, is much hotter than the same burner working at maximum power.

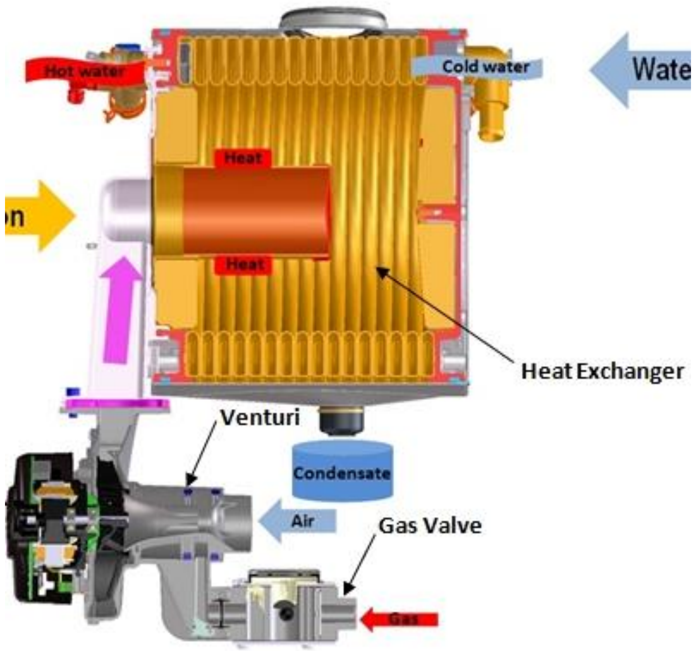




In fact, at minimum power, the flame is shorter, closer to the burner surface, and it can overheatthe burner. This can cause a risk of flashback.

Boiler functionality – Flashback

One of the worst events that can happen during the functionality of a burner, is the flashback (or backfire).



The flame develops where it shouldn't, with a violent effect.

H_2 and CH_4 fuel properties - Comparison

Methane VS Hydrogen

Property	Methane	Hydrogen
Density [kg/m^3]	0.68	0.09
Flammable range [%vol]	4.4-17.0	4.0-75.0
Laminar burning velocity [m/s]	0.4	3.1
Minimum spark ignition energy [mJ]	0.210	0.016
Autoignition temperature [°C]	600	560
Higher Heating Value [MJ/m^3]	39.8	12.7
Lower Heating Value [MJ/m^3]	35.8	10.8

- H_2 flammability range is 5.6 times than CH_4
- H_2 laminar burning velocity is ≈8 times than CH_4
- H_2 ignition energy is very low (less than 1/10 than CH_4)

Burning velocity

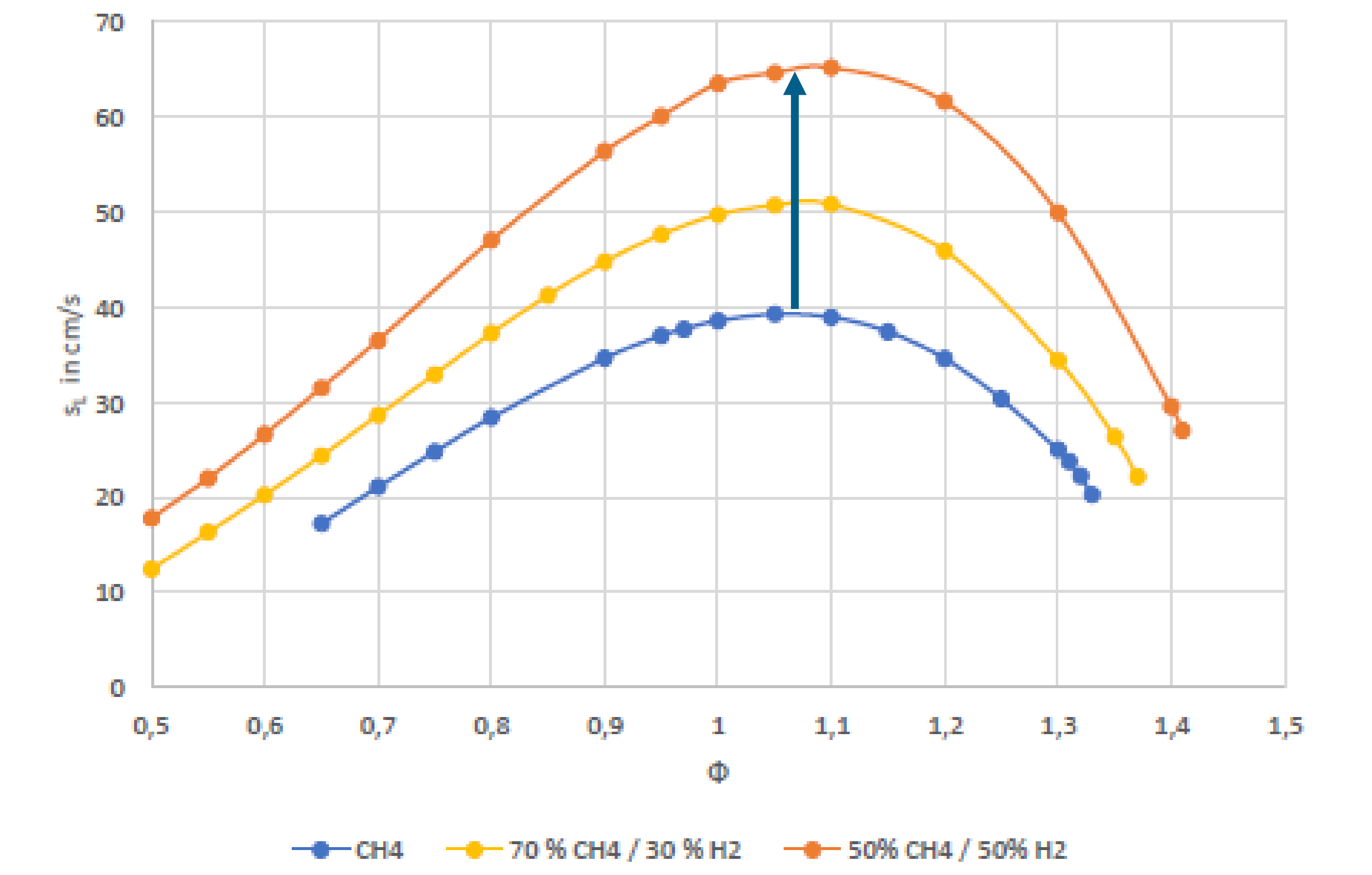
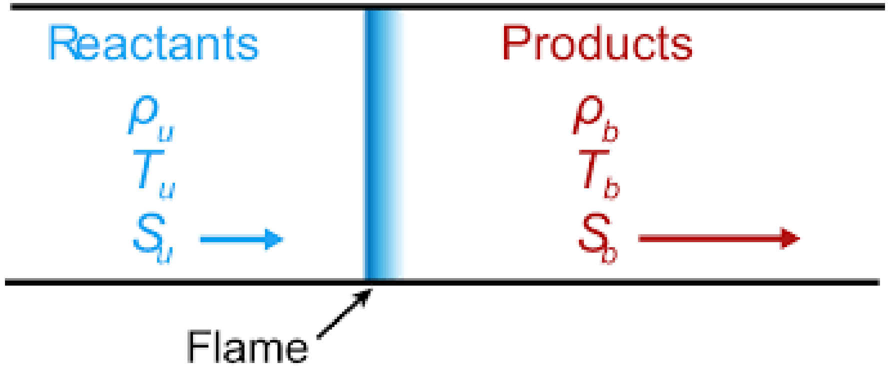


Figure 11: Comparison of laminar combustion velocities of methane, 70% CH_4 / 30 % H_2 and 50 % CH_4 / 50 % H_2

(Extremely) simplified flame stabilization example



Burning velocity and ignition energy

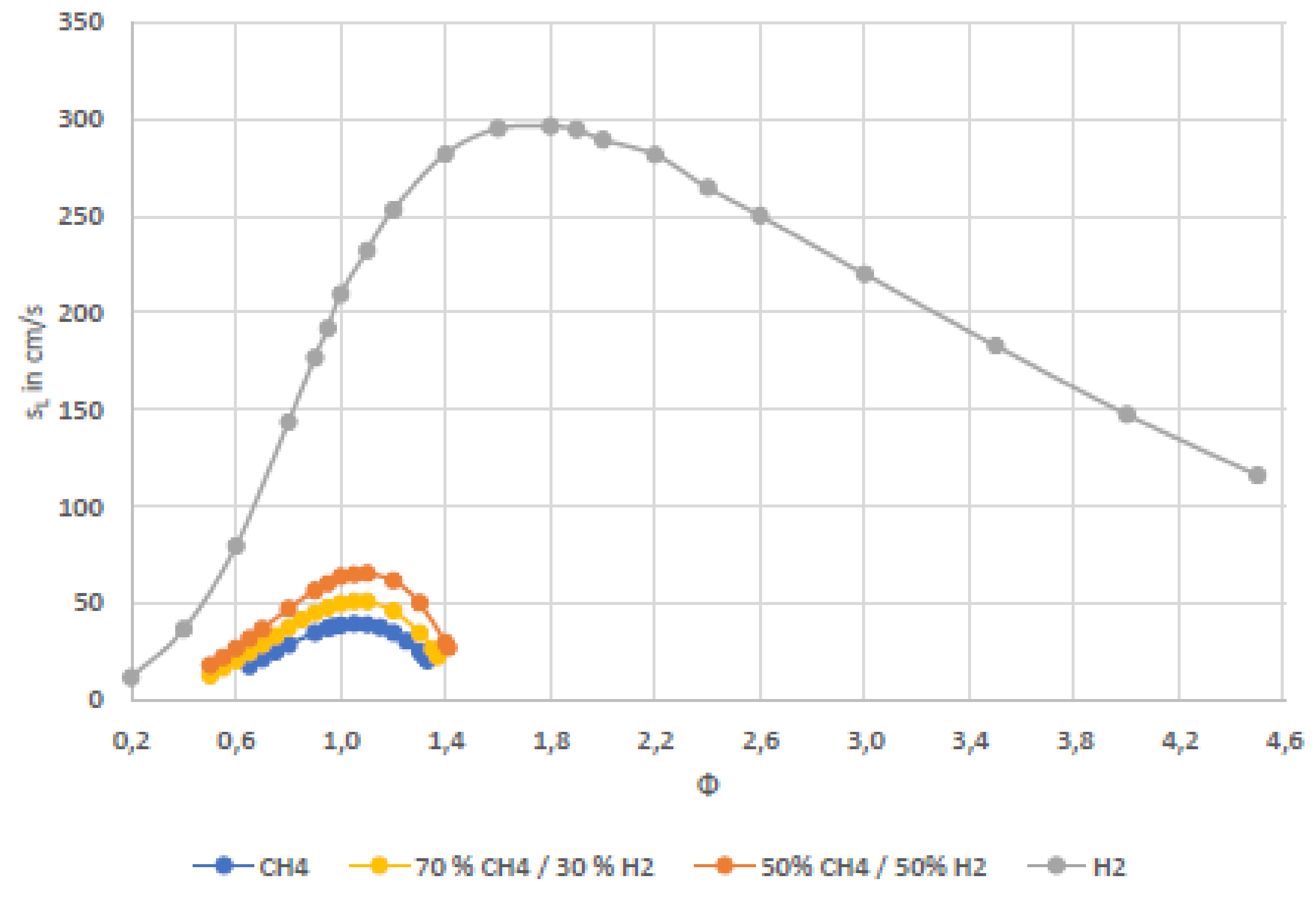
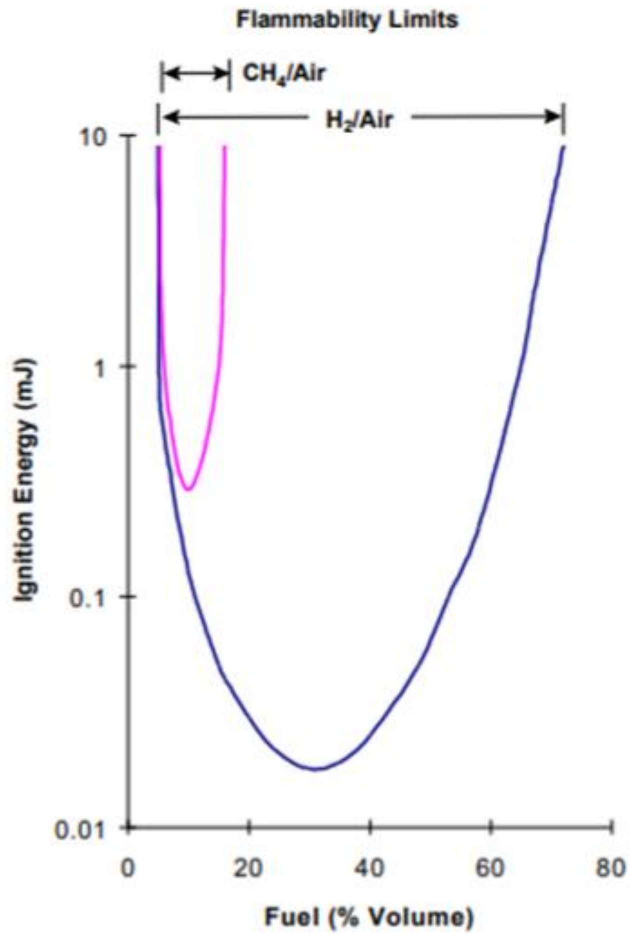


Figure 10: Comparison of laminar combustion velocities of methane, hydrogen and different CH_4/H_2 blends.



Reaction equations for H2/CH4 mixtures

REACTANTS (H_2,CH_4, O_2, N_2)

↓

PRODUCTS (CO_2, CO, H_20, N_2, O_2)

$$fH_2 + (1 - f)CH_4 + \lambda(2 - 1.5f)(O_2 + 3.76N_2) \rightarrow$$

$$\rightarrow (1 - f)CO_2 + (2 - f)H_2O + 3.76\lambda(2 - 1.5f)N_2 + (\lambda - 1)(2 - 1.5f)O_2$$

f = fraction of H_2 [0-100%]

λ = air-fuel equivalence ratio

Flow rates

25 kW thermal load and λ=1.25

	f=0%	f=20%	f=40%	f=60%	f=80%	f=100%
Fuel flow [m^3/h]	2.51	2.92	3.48	4.32	5.70	8.35
Air flow [m^3/h]	29.86	29.51	29.02	28.30	27.12	24.84
Total reactants flow [m^3/h]	32.37	32.42	32.50	32.62	32.81	33.19
CO_2 exhaust [%]	9.17	8.68	7.96	6.84	4.81	0.00

- f=40% → fuel flow ratio 1.4; f=100% → ratio 3.3
- Fuel ducts, gas valve and air/fuel mixer needs to be redesigned for high f
- Blower and mixture ducts do not need redesign, carelessly of f value

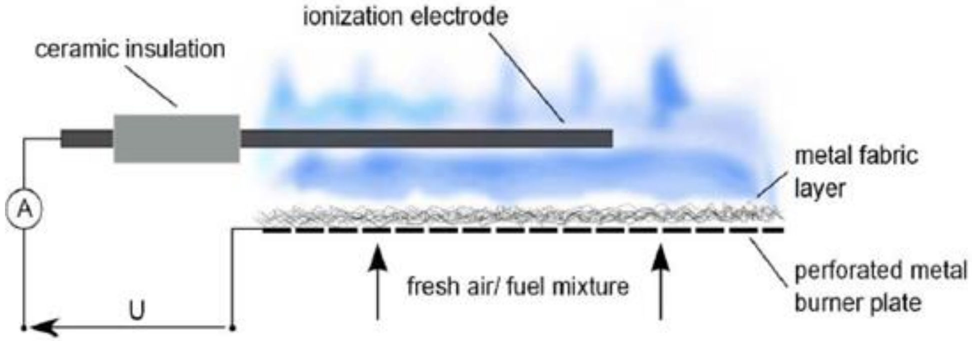
Condensate mass-flow

	f=0%	f=20%	f=40%	f=60%	f=80%	f=100%
Fuel flow [m^3/h]	2.51	2.92	3.48	4.32	5.70	8.35
LHV [MJ/m^3]	35.8	30.8	25.8	20.8	15.8	10.8
HHV/LHV [-]	1.10	1.11	1.12	1.13	1.15	1.18
Water vapour flow [m^3/h]	5.02	5.25	5.57	6.05	6.83	8.35
Max condensable water [kg/h]	3.76	3.93	4.17	4.53	5.12	6.25

- f=0.4 → ≈+20% condensable water
- f=1.0 → ≈+60% condensable water
- Need to redesign condensate trap and discharge

Flame detection and controls

- Flame visibility: H_2 burns with an almost invisible flame. Radiation intensity peaks in UV.
- Ionization controls: ionization current is weakened when H_2 is added (less CH* and H_3O^+ radicals, shift of flame). Need to redesign, or re-tune, controls.
- Pure hydrogen combustion does not allow for detection of ionization current (mainly driven by CH* radicals, absent in this case).



Leakages and sealings

- Tightness of the gas circuit is more critical for hydrogen than for methane.

- Gas permeability of materials has to be evaluated carefully. For example, silicon sealings are not suitable due to the high permeation rate with hydrogen.

- High diffusivity: proper materials. E.g. Nylon PA-12 is 50 times more permeable to H_2 than to CH_4. PA-11 is interesting.

Research facilities at Polidoro

7 DEDICATED TEST ROOMS

2 rooms ready for 100% H2 and methane/hydrogen blends, up to 100kW and 1 room up to 350kW

HEMI-ANECHOIC ROOM

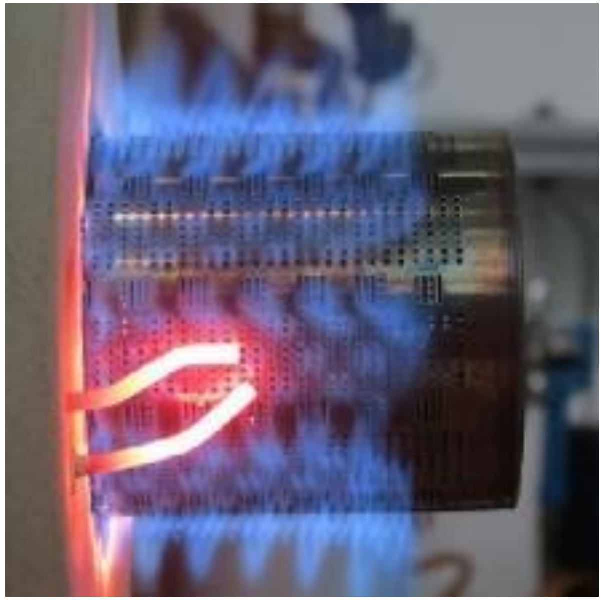
Class 1 room for sound power level tests

TESTS

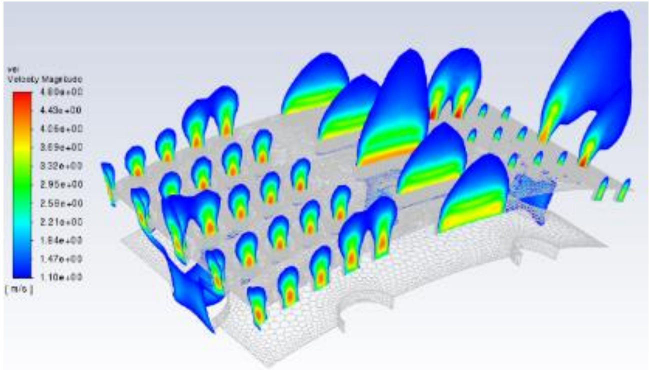
Capacity
Emissions
Life and Stress tests

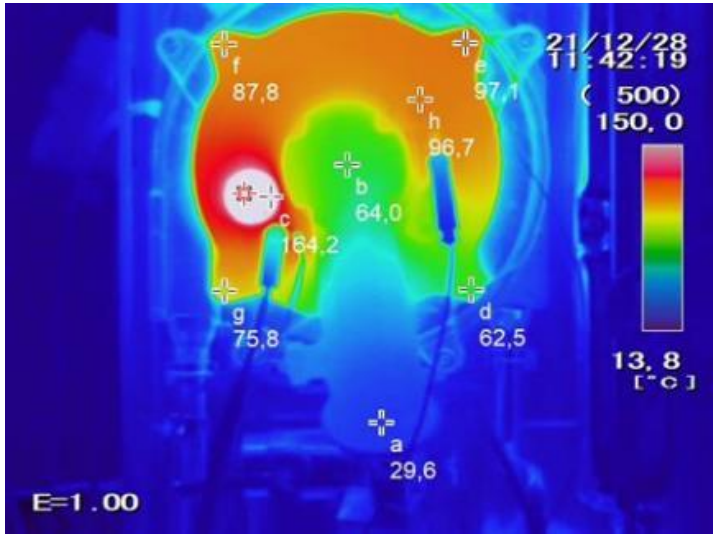
R&D capability

Laboratory testing



FEM analysis (flow, combustion, structural)





H_2 Lab – Fuel preparation

- Hydrogen/methane mixer, in a protected structure
- 100% H2 or CH4/H2 mixtures
- Up to 100 kW power

H_2 Lab – Fuel delivery lines

H_2 Lab – Lab Analyzers

Additional analyzers needed

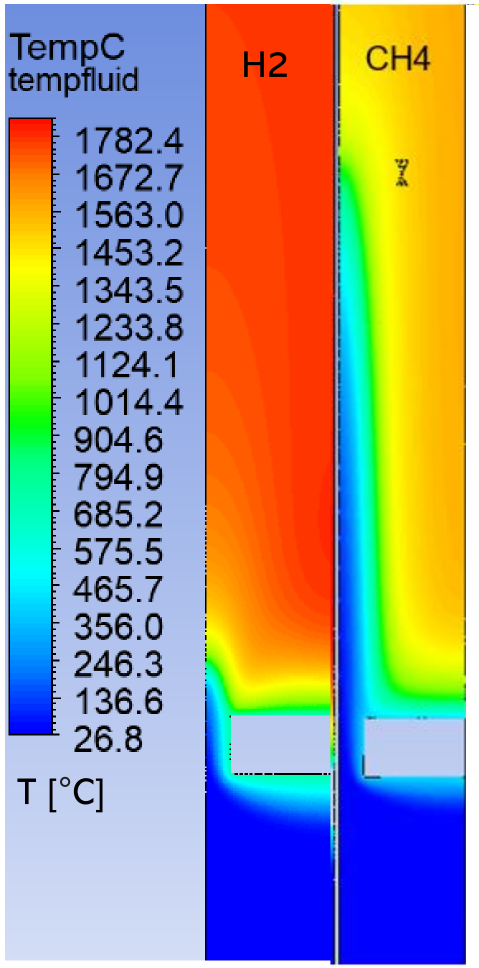
- H_2 analyzer
- O_2 analyzer
- Unburnt H2 analyzer
- Fuel flow meter
- ....

H_2 Lab – Safety

- Fuel leakage detection
- PPE (Personal Protection Equipment)
- Safety procedures
- Safety - hardware sensors

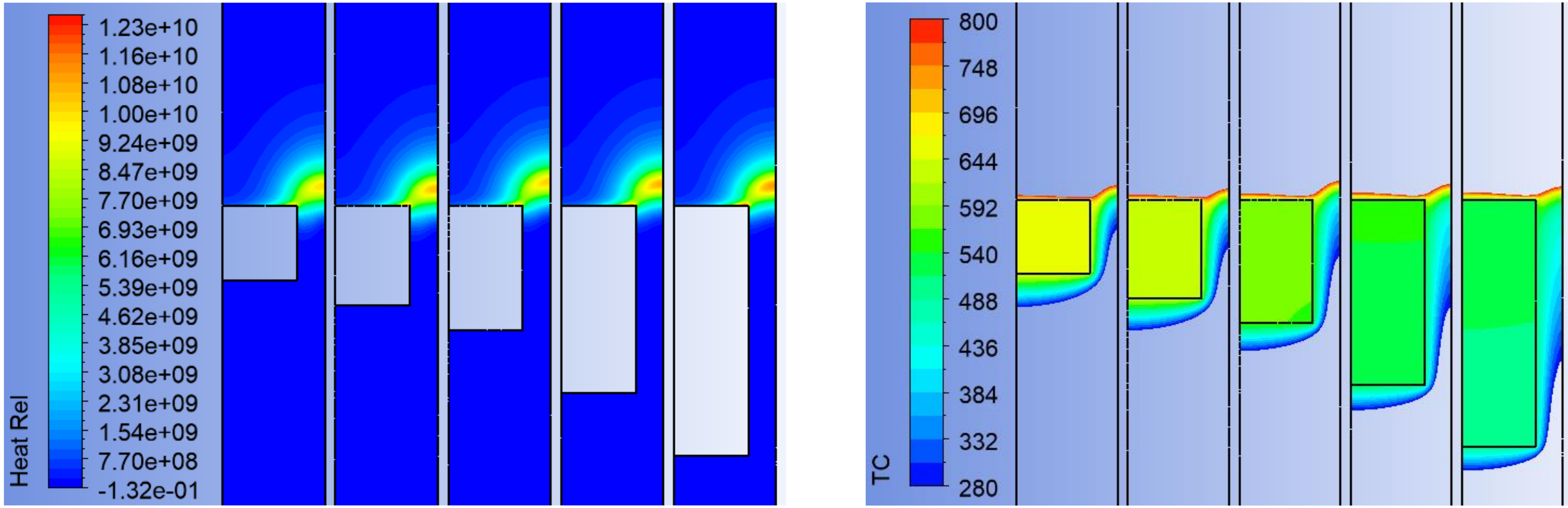
CFD/FEM simulations

Example of CFD results: at the same power and lambda the hydrogen flame is much closer to the burner



Thickness – Simulation

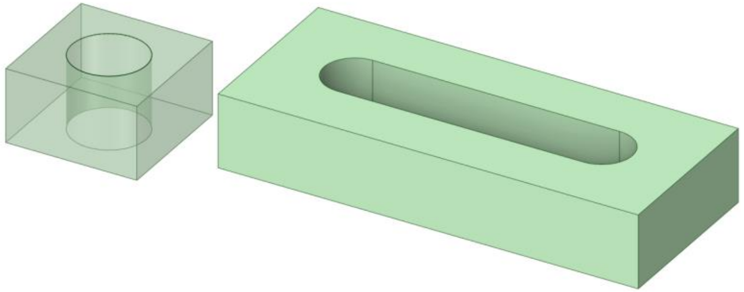
- Comparing 5 cases: t=0.6, 0.8, 1, 1.5 and 2mm
- For larger thickness, the mixture gets hotter as it flows through the passage

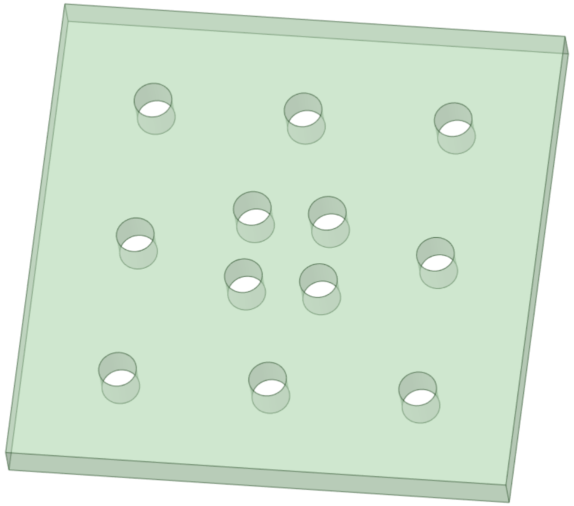


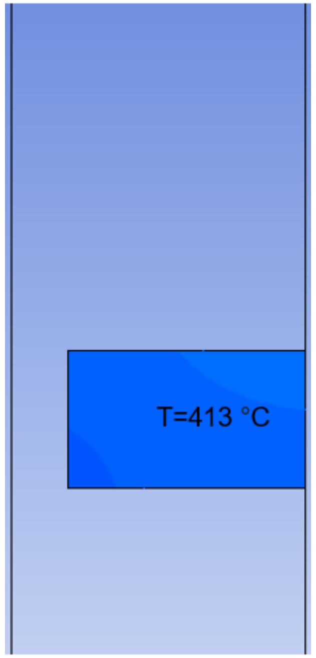
Conclusion:

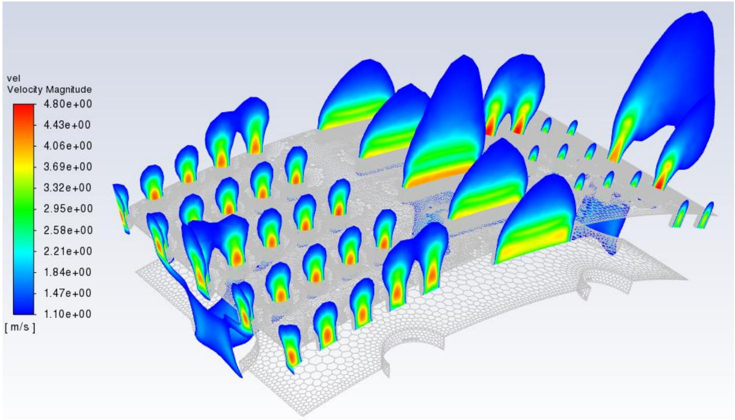
- A larger thickness has the positive effect of the burner temperature reduction
- The negative effect of the larger thickness is a higher level of preheating of the unburnt mixture

Complexity - Simulation



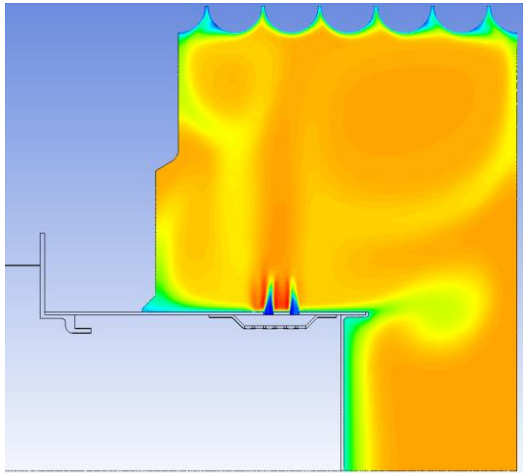


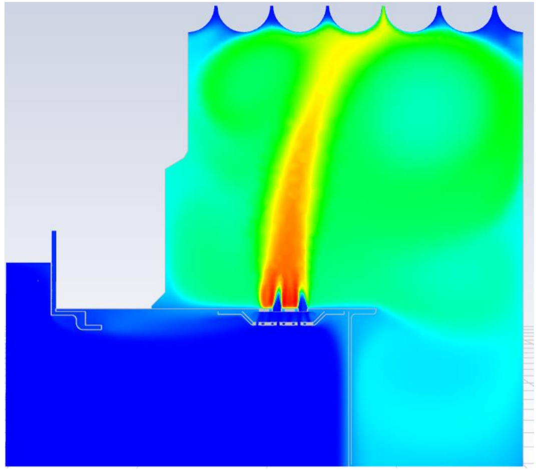


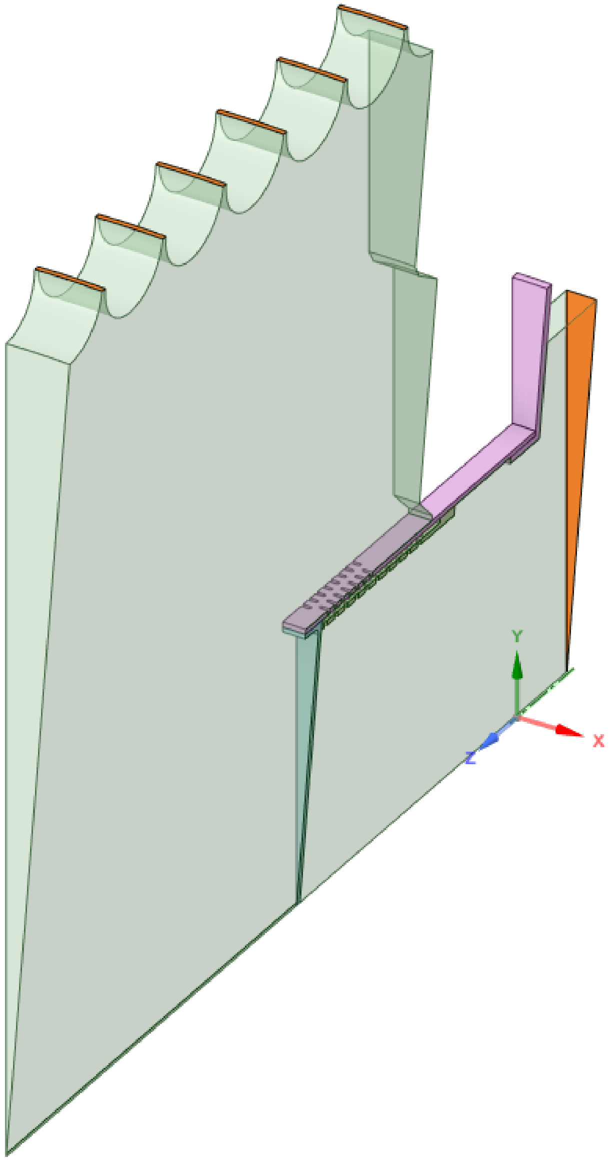


Complexity - Simulation

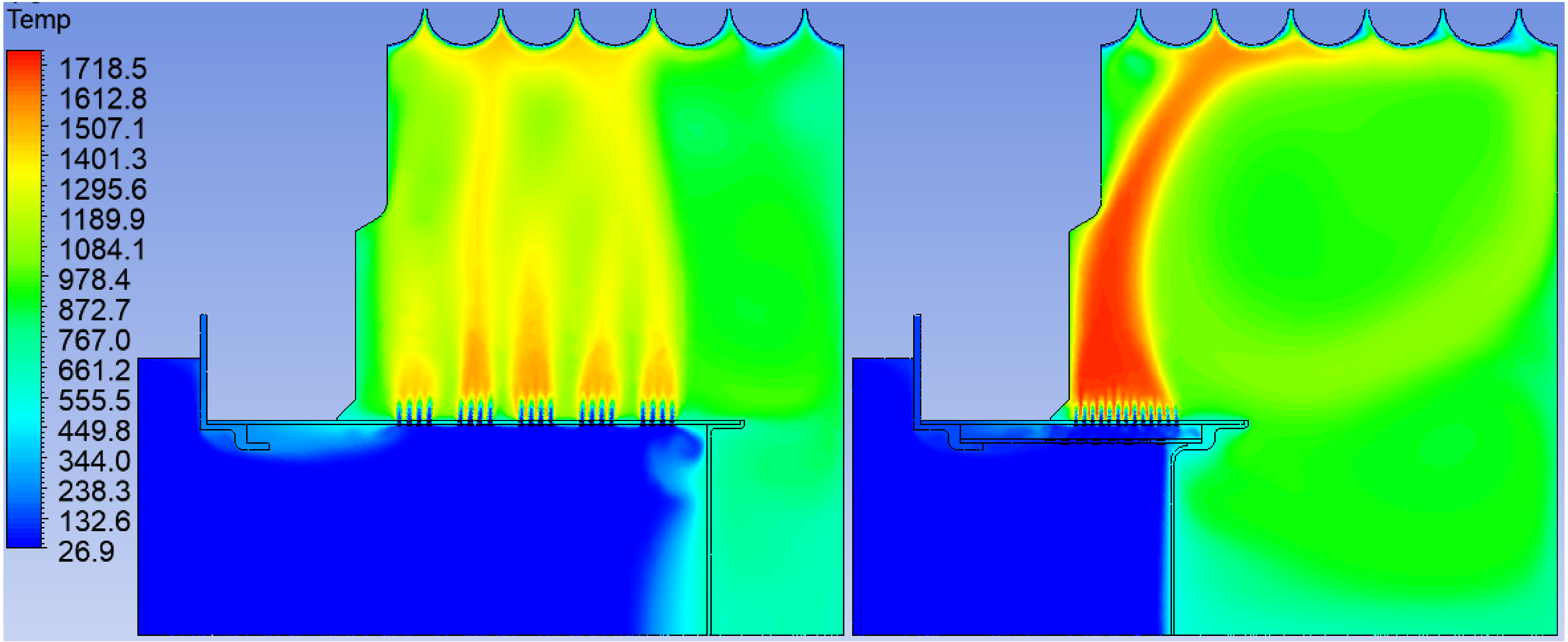
- Including all elements: distributor, burner, combustion chamber, insulations and heat exchanger
- Taking a small sector, symmetries on both sides





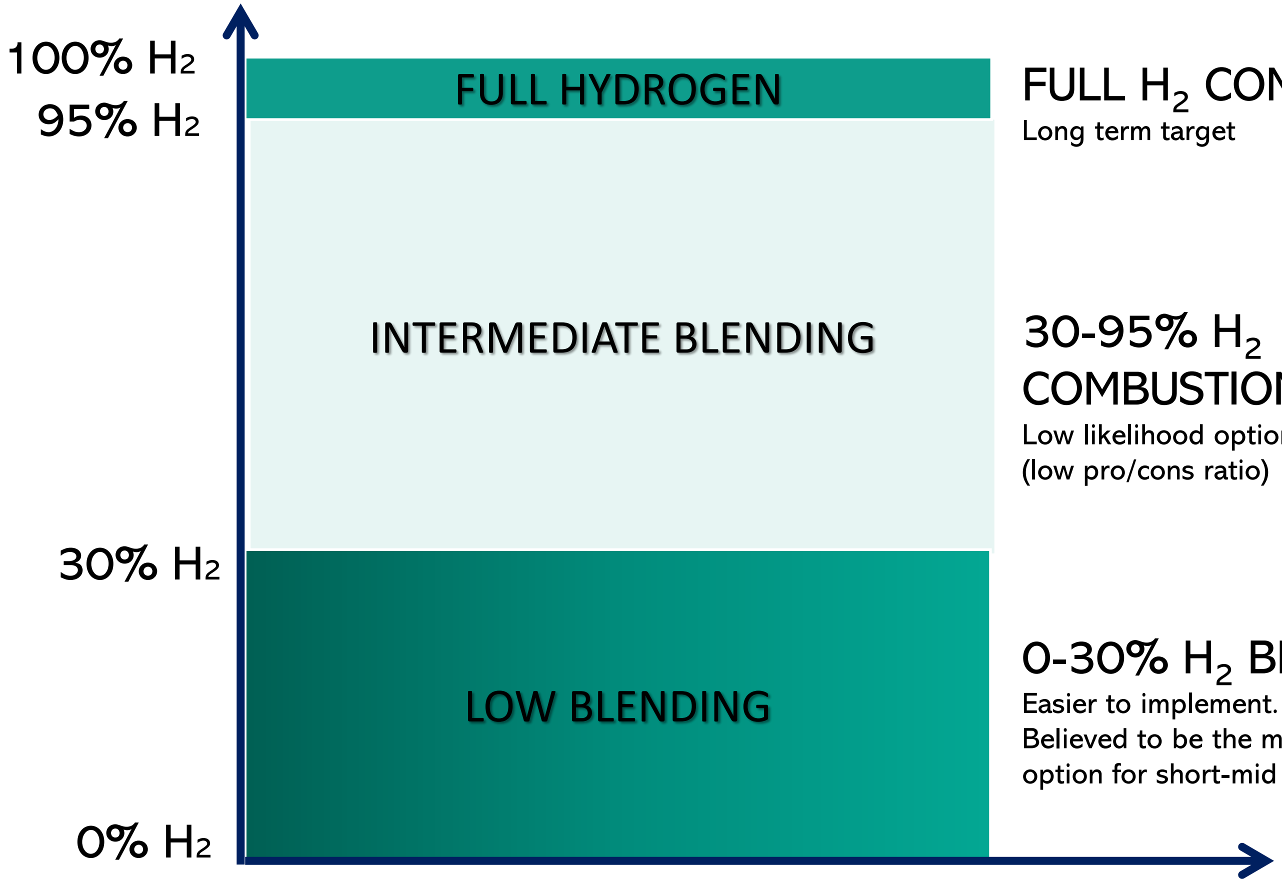


Complexity - Simulation



Burners supplied with CH_4-H_2 blends

“Hydrogen enrichment” scenarios



FULL H_2 COMBUSTION
Long term target

30-95% H_2 COMBUSTION
Low likelihood option
(low pro/cons ratio)

0-30% H_2 BLENDING
Easier to implement.
Believed to be the most probable option for short-mid term

Testing existing burners with blends

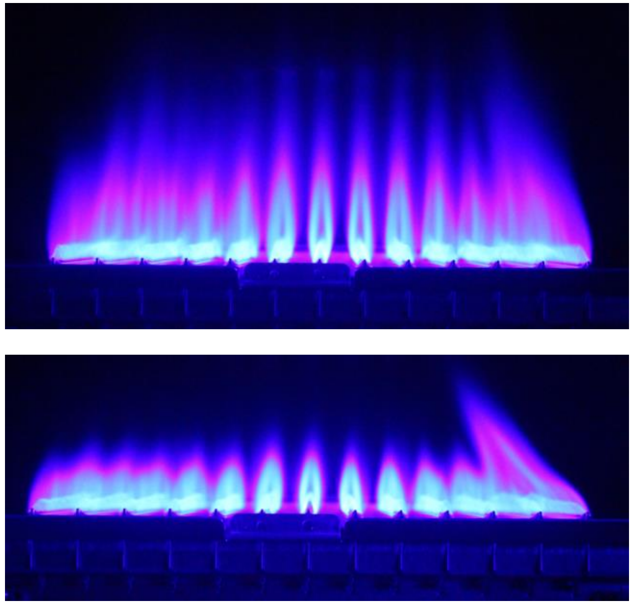
The target of this activity is to study the functionality of the current burners, supplied with a CH_4-H_2 mix.

The tests have been carried out with:

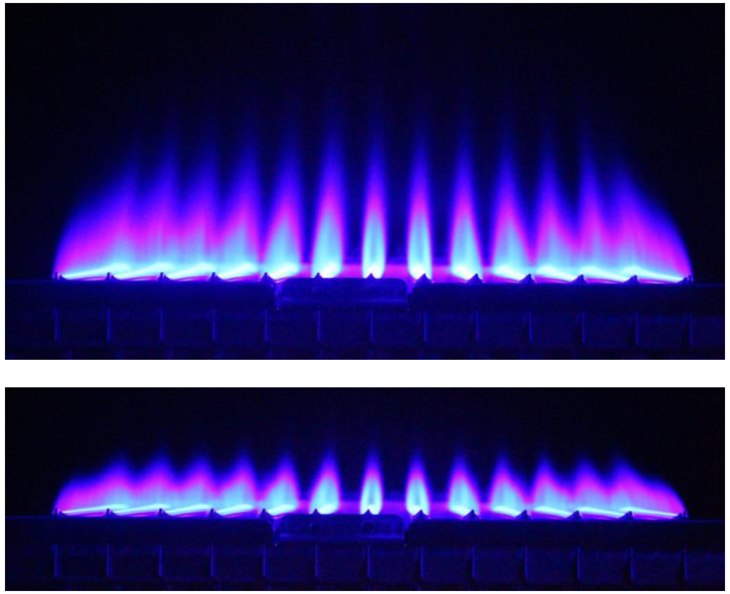
- G20 (0% H_2 - 100% CH_4)
- G222 (23% H_2 – 77% CH_4)
- Mix 1 (40% H_2 – 60% CH_4)
- Mix 2 (60% H_2 – 40% CH_4)

Atmospheric Burners - NP – Free Air

When the %H_2 increases, the flame becomes more and more adherent to burner surface (flame stability).



G20 (100% H_2)



60%H_2- 40%CH_4

Atmospheric Burners – Boiler test

GAS	P [mbar]	Esito	Tempo trascorso
23H77M	2,07	PASS	>10'
	2,20	PASS	>10'
	6,20	PASS	>10'
40H60M	2,07	PASS	>10'
	2,20	PASS	>10'
	6,20	PASS	>10'
	11,10	PASS	>10'
	12,75	PASS	>10'
60H40M	2,07		
	3,00	FAIL	<1'
	6,20	FAIL	2'30''
	11,10	PASS	>5'
	12,75	PASS	>5'
PERMANENZA PER OGNI CONDIZIONE: 10 MINUTI			

Checking the behaviours at Qmin, the flashback happens regularly with Mix 2, at medium-low pressure, after few minutes.

Premix – Boiler test

The burner behaviour, with different gas blends, has been evaluated taking in account:

- Thermal Load and Emissions
- Flashback resistance
- U-curve (CO vs CO2)

Premix – Boiler test: flashback

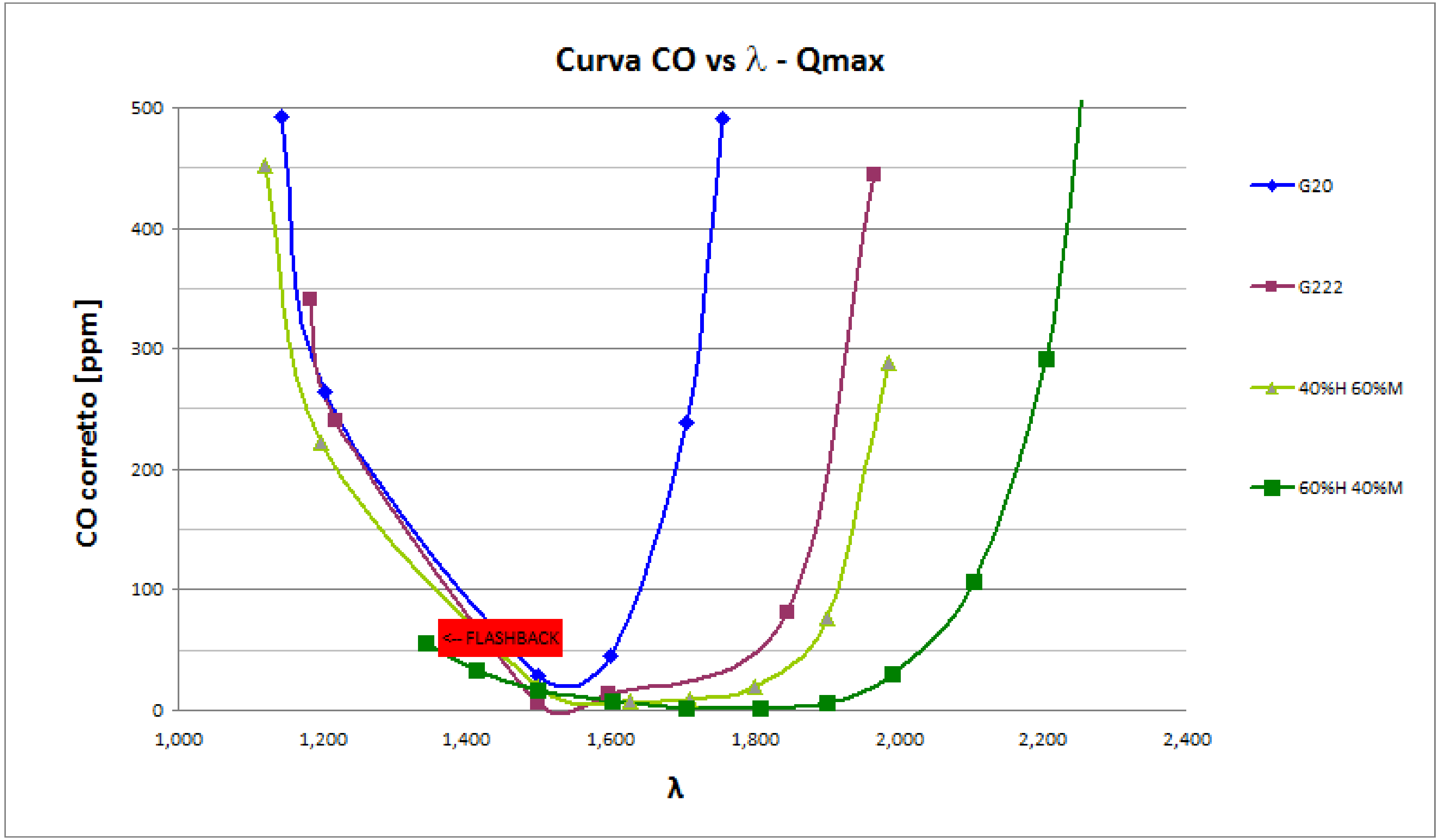
n = 1000 rpm			
GAS	λ	Esito	Tempo trascorso
G222	1,106		
	1,043	PASS	> 10'
	1,014	PASS	> 10'
40H60M	1,300	PASS	> 10'
	1,200	PASS	> 10'
	1,100	PASS	> 10'
	1,048	FAIL	6'30"
	1,000	FAIL	immediato
60H40M	1,400	FAIL	immediato
	1,300		
	1,200		
	1,100		
	1,000		
PERMANENZA PER OGNI CONDIZIONE: 10 MINUTI			

λ	Esito	Tempo trascorso
1,100	PASS	> 10'
1,050	PASS	> 10'
1,010	PASS	> 10'
1,280	PASS	> 10'
1,194	PASS	> 10'
1,094	PASS	> 10'
1,072	FAIL	< 1'
1,000		
1,392	FAIL	< 5'
1,300		
1,200		
1,100		
1,000		
PERMANENZA PER OGNI CONDIZIONE: 10 MINUTI		

Analizing the behaviour at Qmin, both the burners when close to the stoichimetric condition, are at risk for flashback already with Mix 1 (40% H2).

Premix – Boiler test: U-curve

Adding H2 entails a increment of the flame stability. This effect is pointed up by the widening of the U-Curves towards higher l values.



Blending – Conclusions

- Existing methane burners can be used with a low blending of hydrogen, till a certain threshold that varies with the application

- Higher blending can not be sustained at all by the current burners, and need a dedicated design.

THyGA

Testing **Hy**drogen admixture for **G**as **A**pplications

Interesting documents made available by this study (THYGA)

Burners for premixed boilers 100% H2

Principal Issues for Hydrogen Boilers

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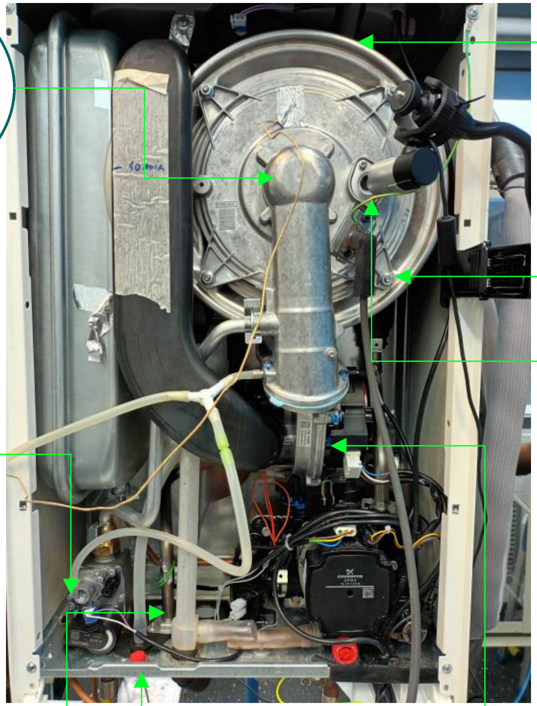
for excellence in combustion
consolidated know-how

Flashback Prevention:
Hydrogen has a higher flame speed than natural gas. One of the fundamental technical advances in hydrogen boilers is burners which can hold a stable hydrogen flame against its high speed

Gas-Air Ratio Control

Condensate
Hydrogen produces significantly more condensate than natural gas.



Performance:
Hydrogen appliances will perform very similarly to natural gas boilers in terms of output efficiency and emissions. The products of combustion are very clean.

Conversion:
To minimize the impact of the conversion on end-users and installers, boilers will be developed to be quickly and easily re-configured for hydrogen on conversion day.

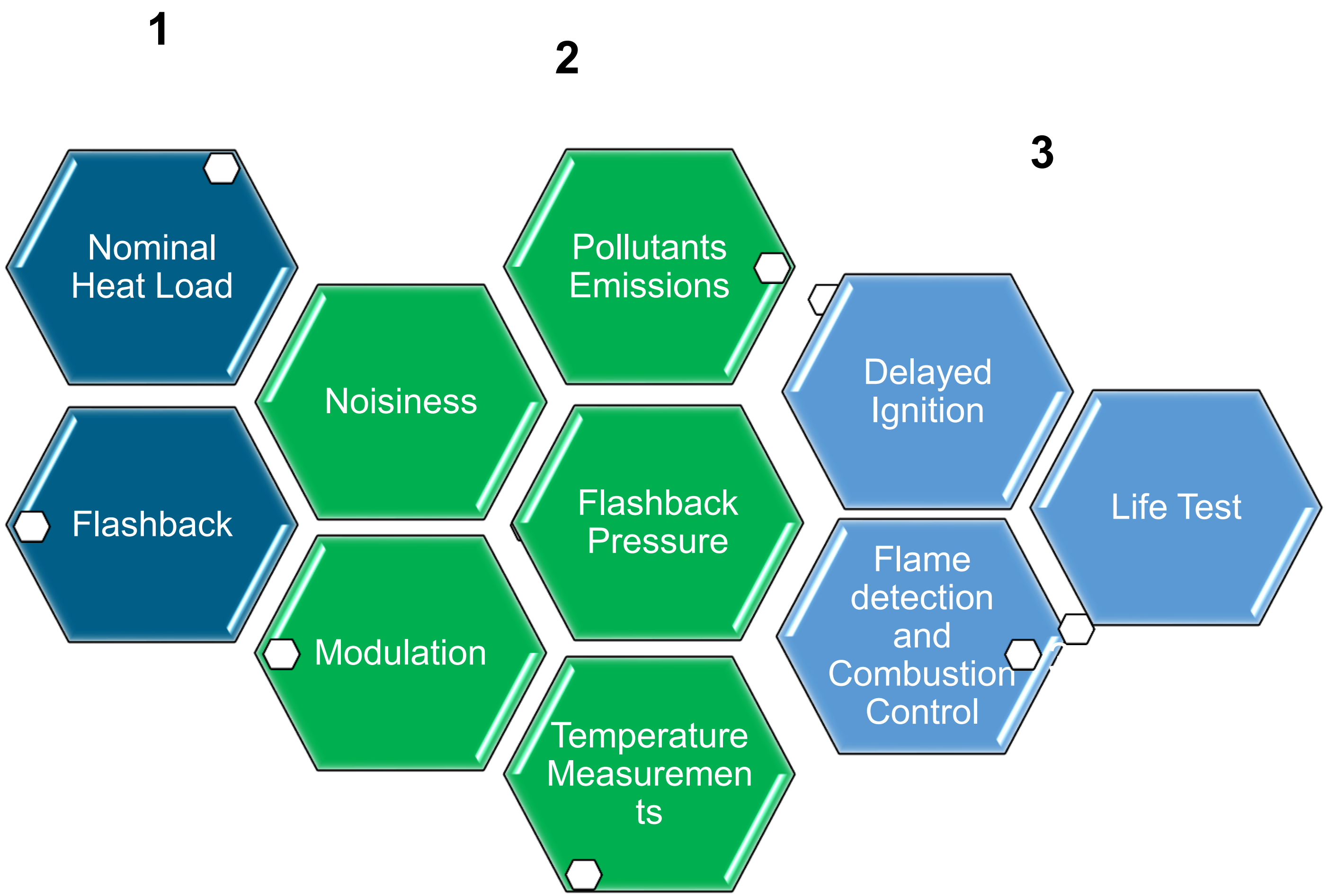
Flame Detection:
Hydrogen flames are invisible and create no electrical signal, but we can detect them by their ultra-violet (UV) emissions.

Gas-Tightness:
Hydrogen has a small molecule that can leak through a small opening

Materials Compatibility

H2 dev projects – targets of development

We analyse different design parameters, ordered by priority



Flashback – Burner related aspects

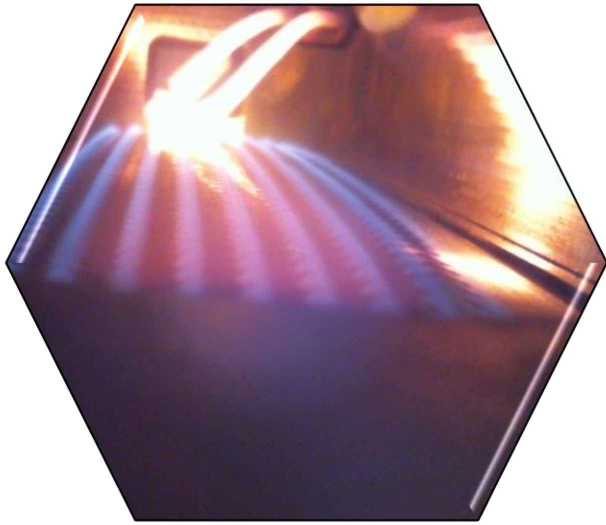
- **High flame speed** and **low ignition** energy lead to undesired ignitions of the mixture, upstream of the burner, in several conditions.

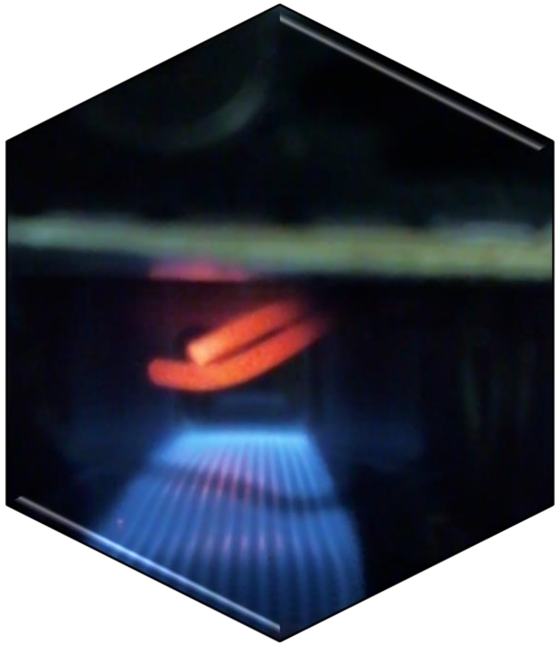
- A **proper pattern** of holes and a proper geometry for holes has to be defined (shape/diameter and pitch between perforations).

- Flashback phenomenon is very **sensitive to thermal load**.

Flashback/Modulation

- We investigate the flashback limits for different thermal loads to define the safe operating conditions for the boiler.
- Higher is the modulation rate, and lower is the minimal heat load.
- At lower heat loads flashback prevention is more challenging (lower speed, flame closer to burner, higher temperatures...)



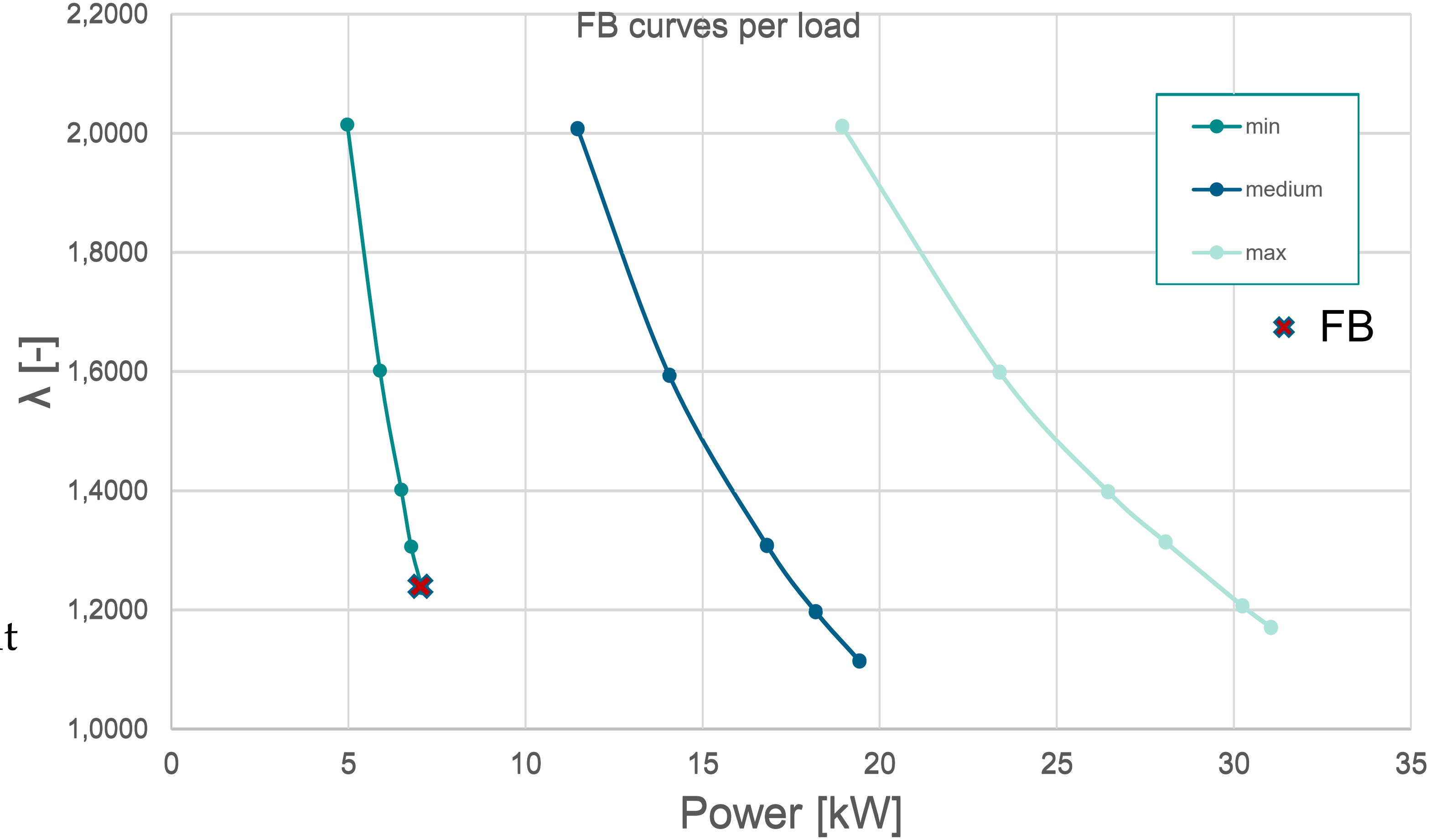


Hydrogen burner development

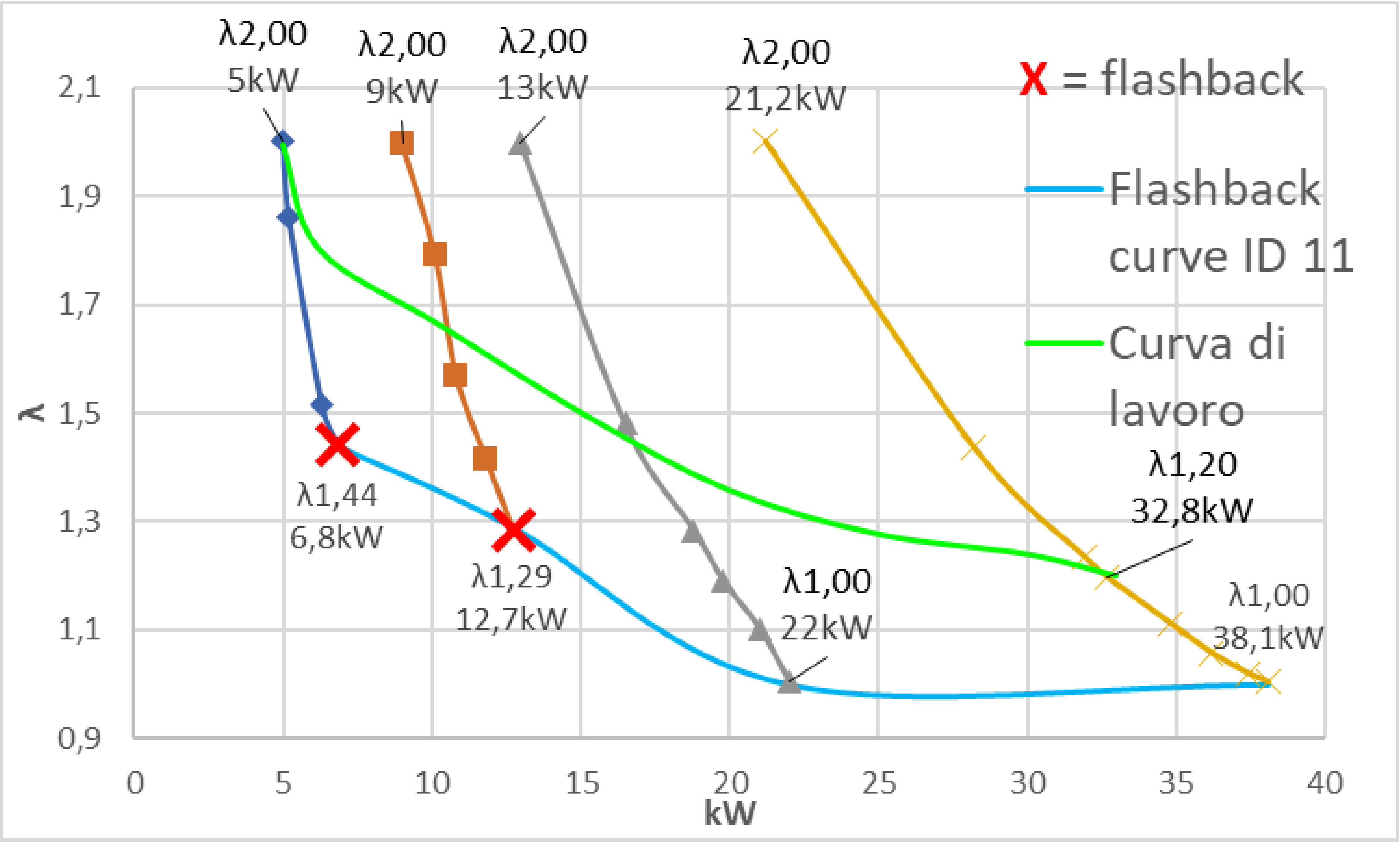
Test procedure

Flashback at stable operation

- Finding flashback limits at minimum, medium and maximum load
- For each load the fan speeds is fixed starting from a defined λ (e.g. λ=2.0)
- Then we decrease the λ acting on the gas valve
  - Till flashback occurs
  - Or until the valve is fully open
- As an example, for 5-30 kW boiler: start at λ=2.0, min@5kW, medium@11.5kW, max@19kW



Flashback curve

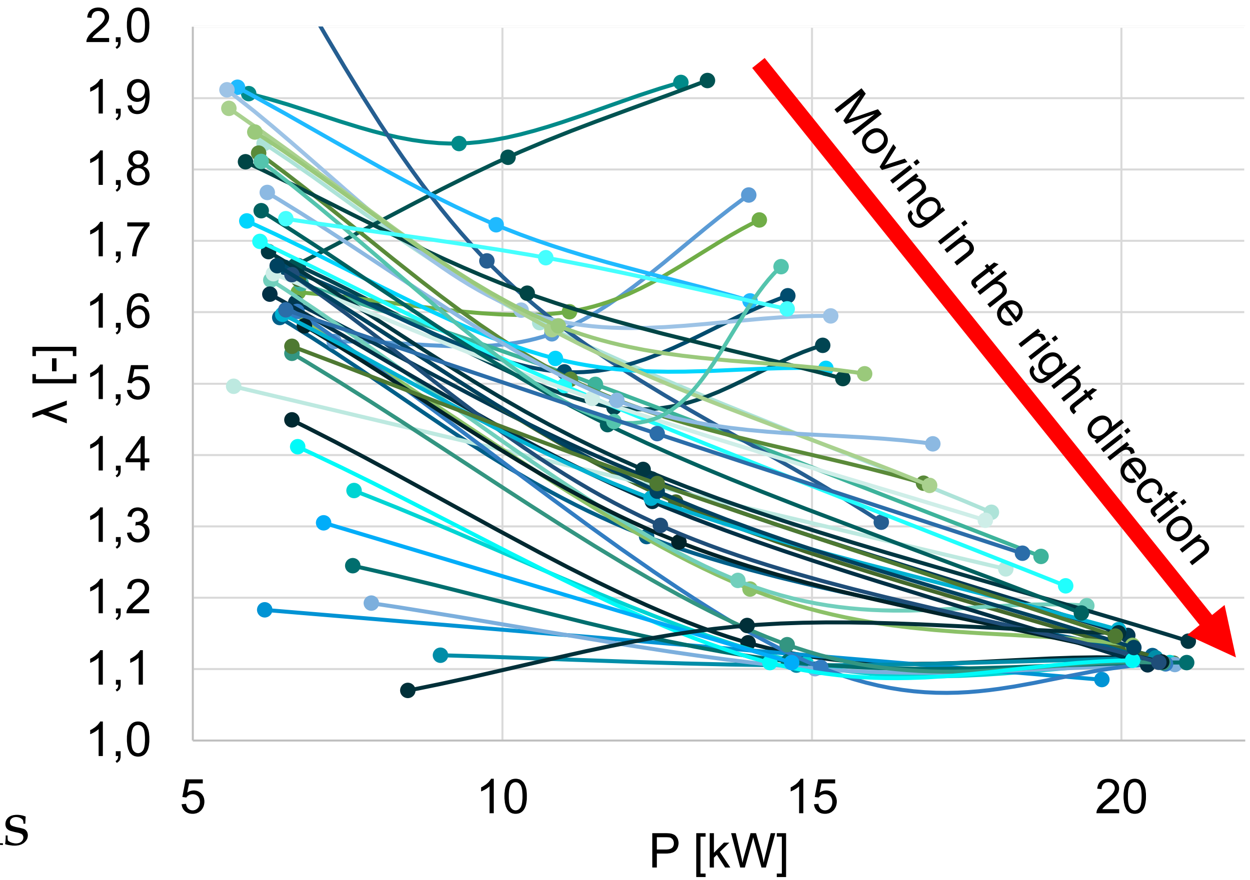


Hydrogen burner development

Changing geometrical parameters of burners

Perforation:

- Open area (A_{open})
- Thickness (t)
- Porosity (φ)
- Protrusion
- Holes vs. slots
- Dimensions (hole Ø, slot l×w)
- Local porosity
- Fiber



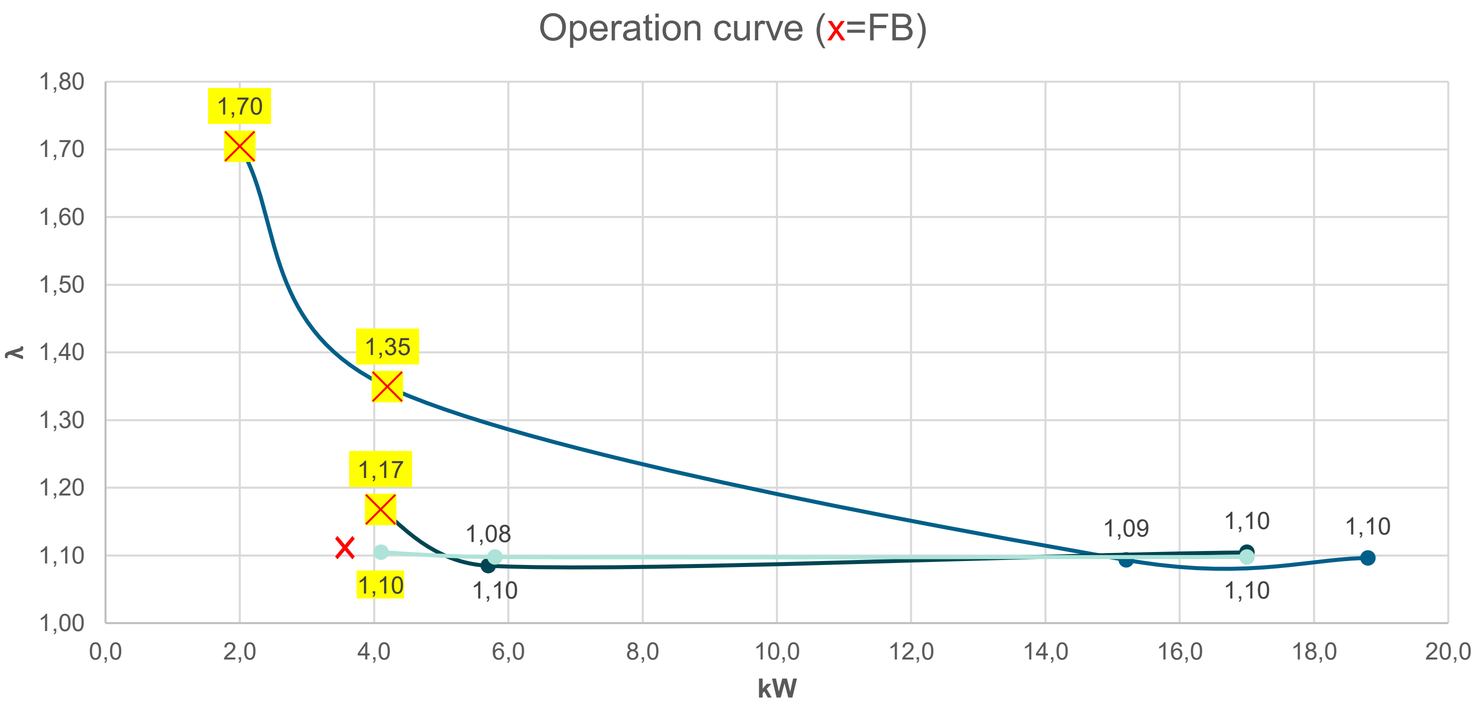
Performing experiments and simulations

Different open area

Burner	Area	Pressure drop at 60m3/h
311.6	600	1300
445	450	1600
444	380	2200

- With a larger open area there are less pressure drop and more power with the same fan speed

- With a lower area the flashback at minimum power is lower



Different types of external perforation

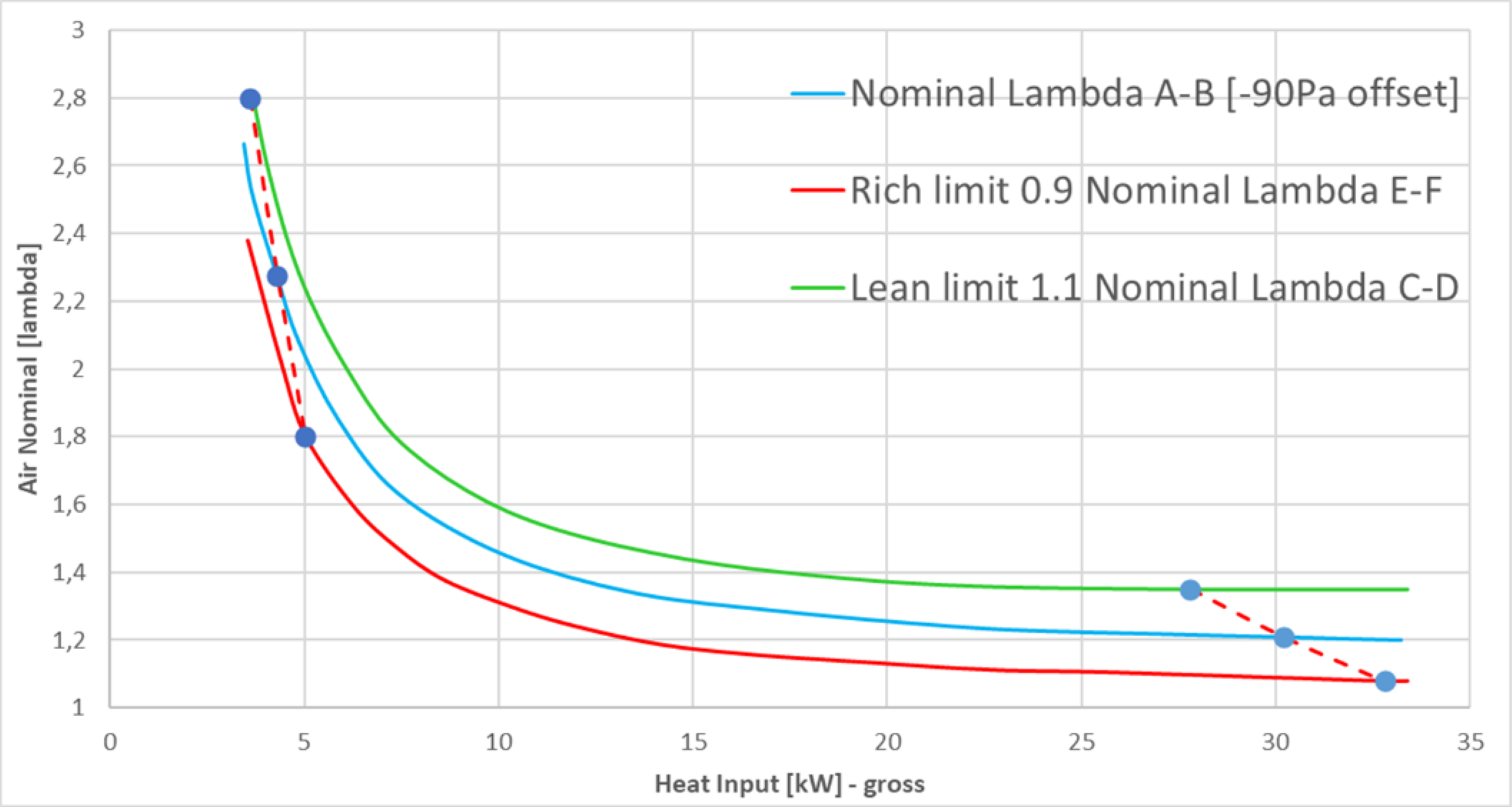
ID_445

Open area=472mm^2

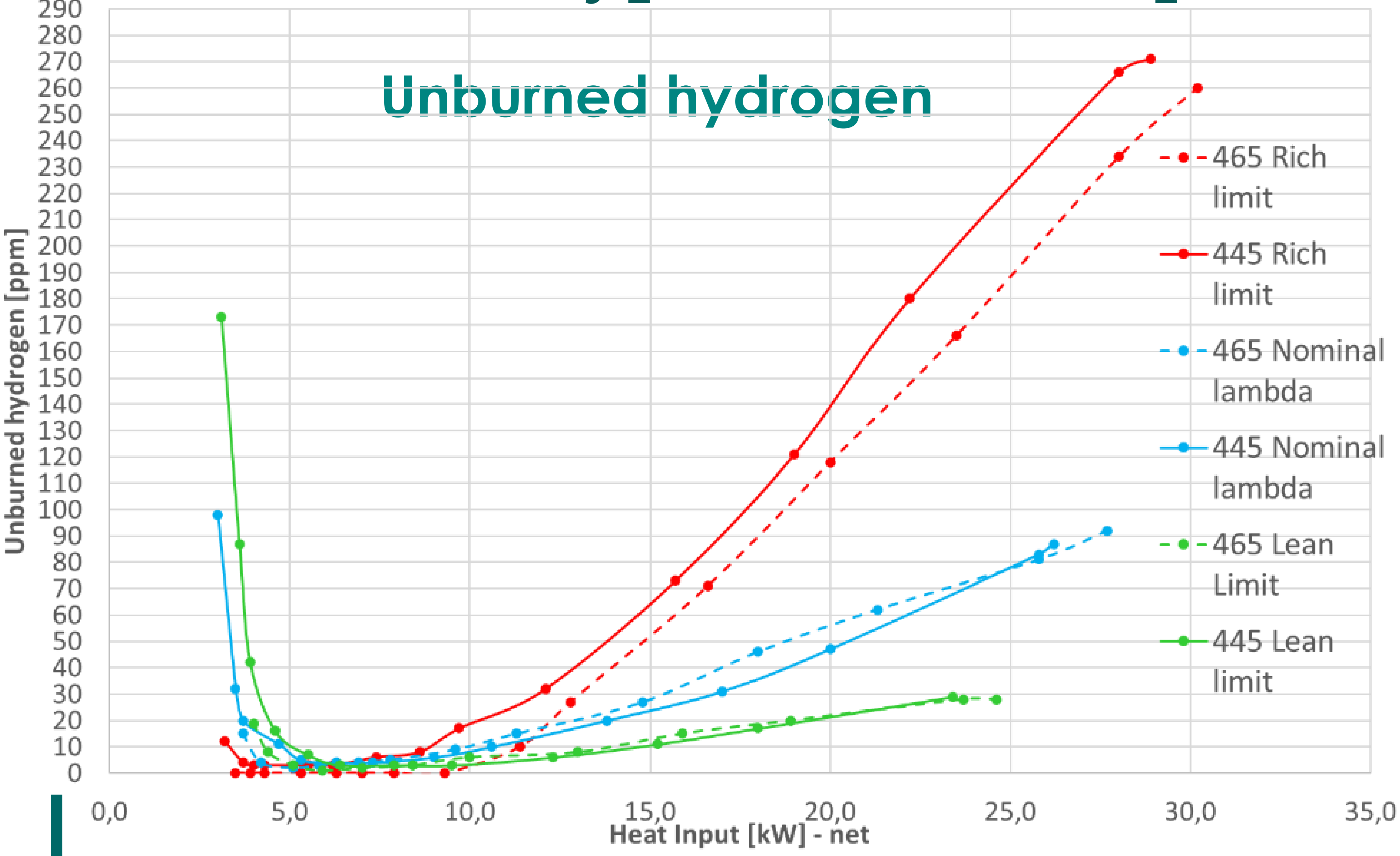
ID_465

Open area=454mm^2

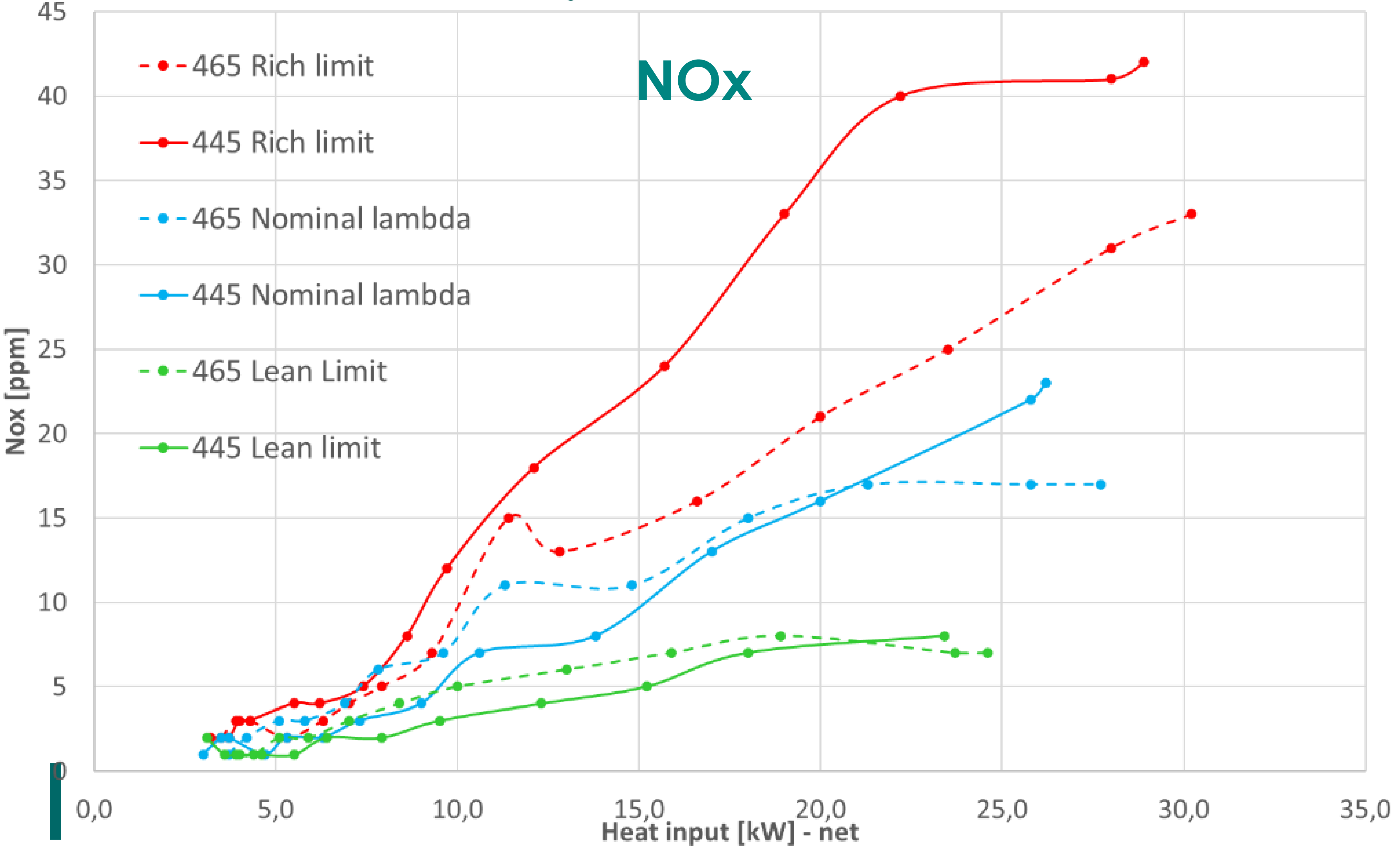
Different types of external perforation



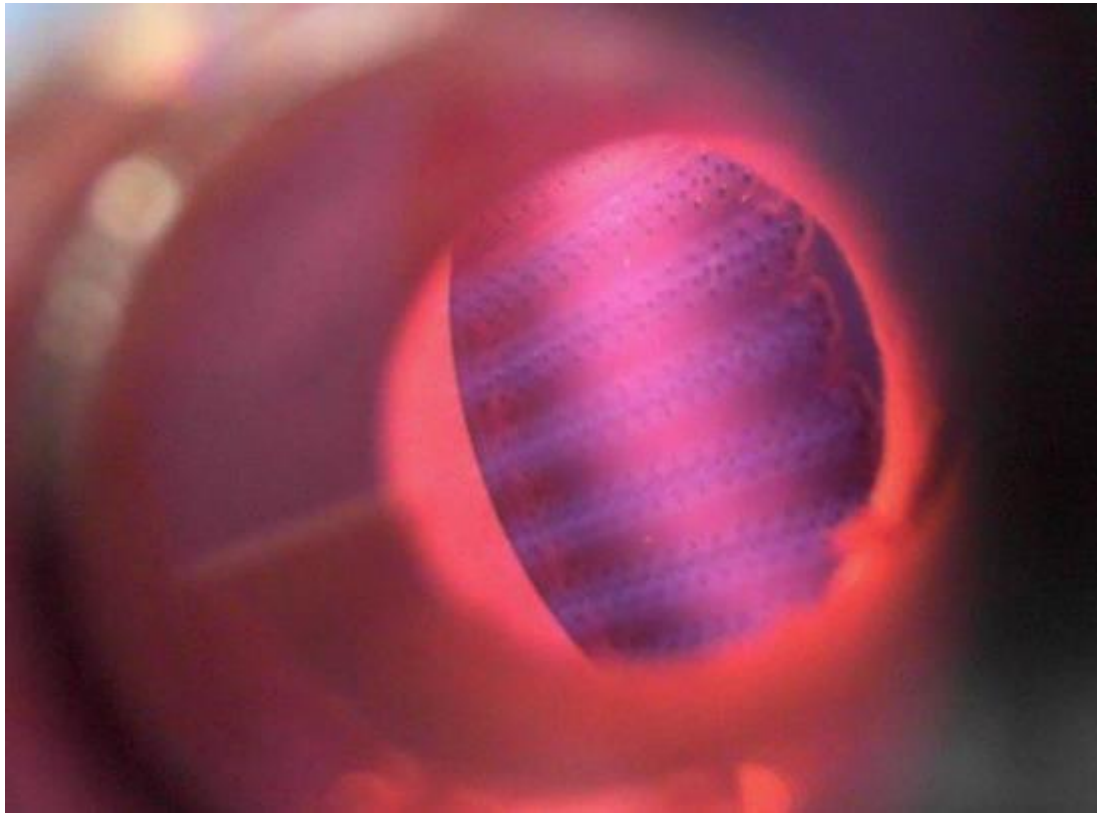
Different types of external perforation



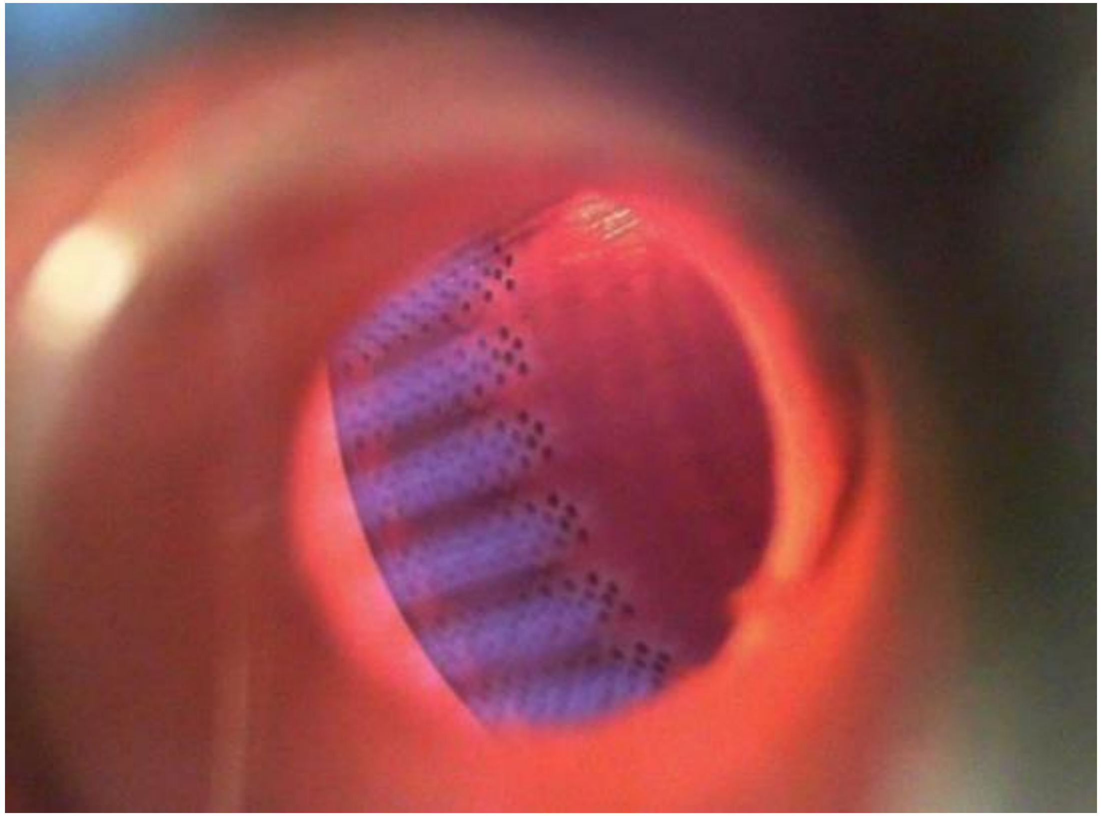
Different types of external perforation



Example of different flame patterns



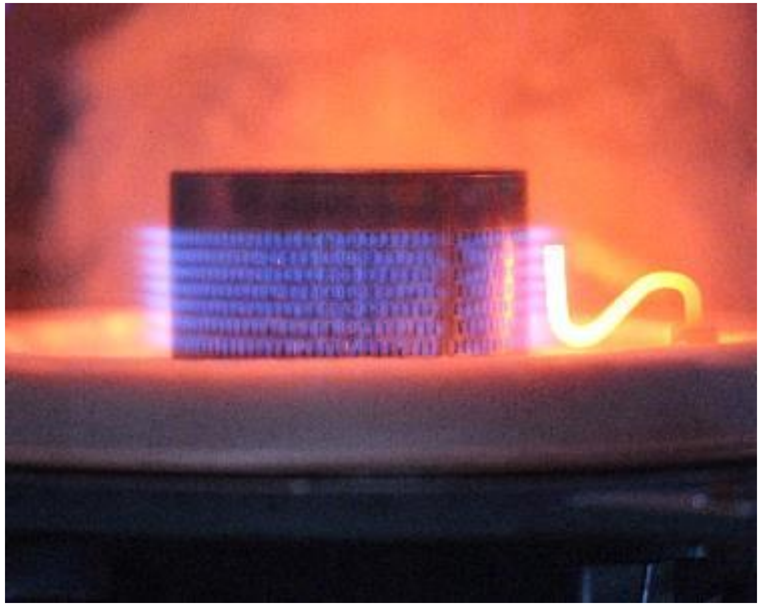
Id_08.1: holes Ø0,6



Id_09.1: holes Ø0,8

Types of burners

Cylindrical

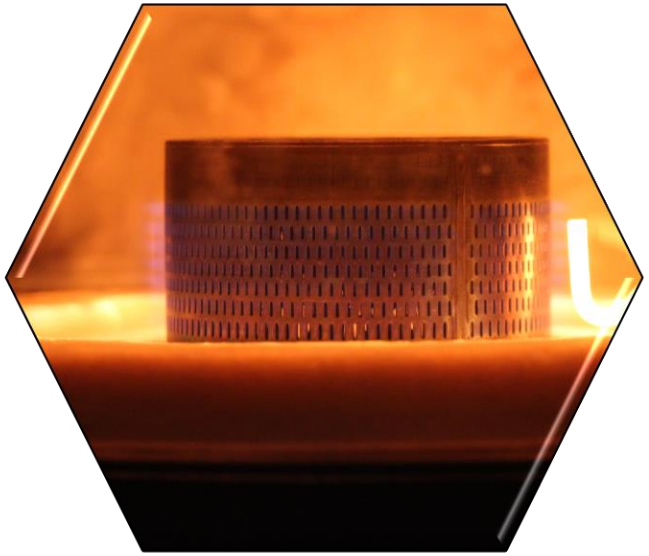


Flat

Flame detection and combustion control

- Hydrogen flame detection and combustion control are different than those for methane.

- Polidoro can support the development of detection systems (UV, temperature sensors, etc.)

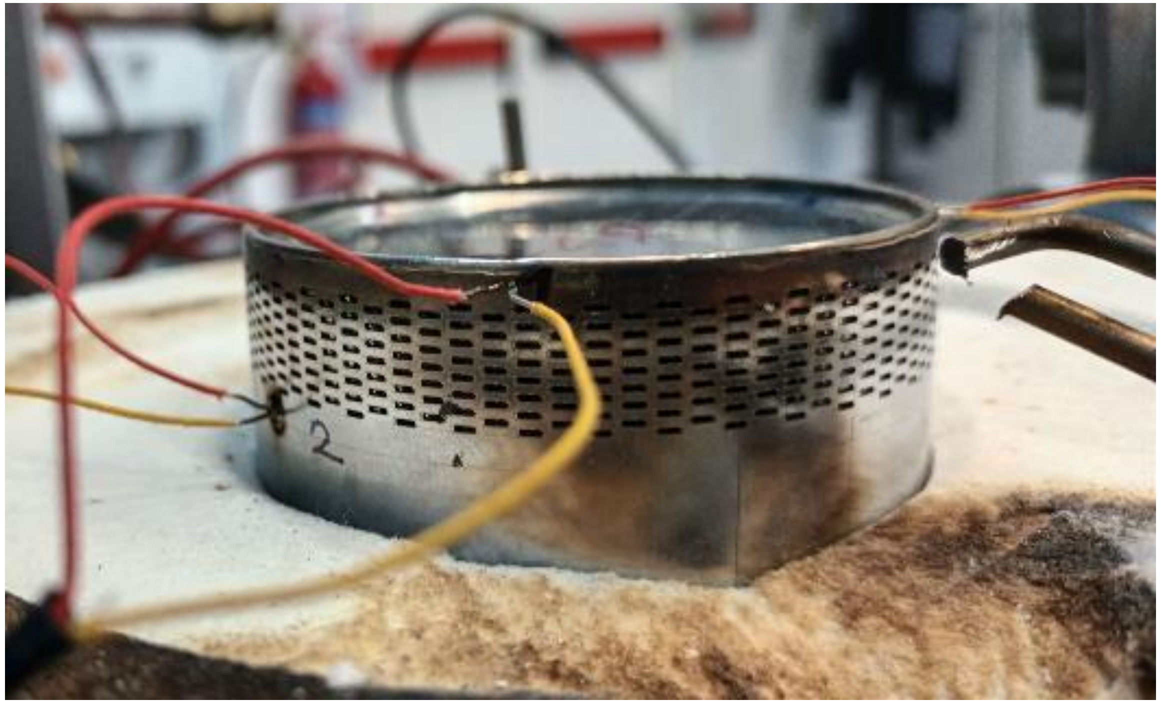


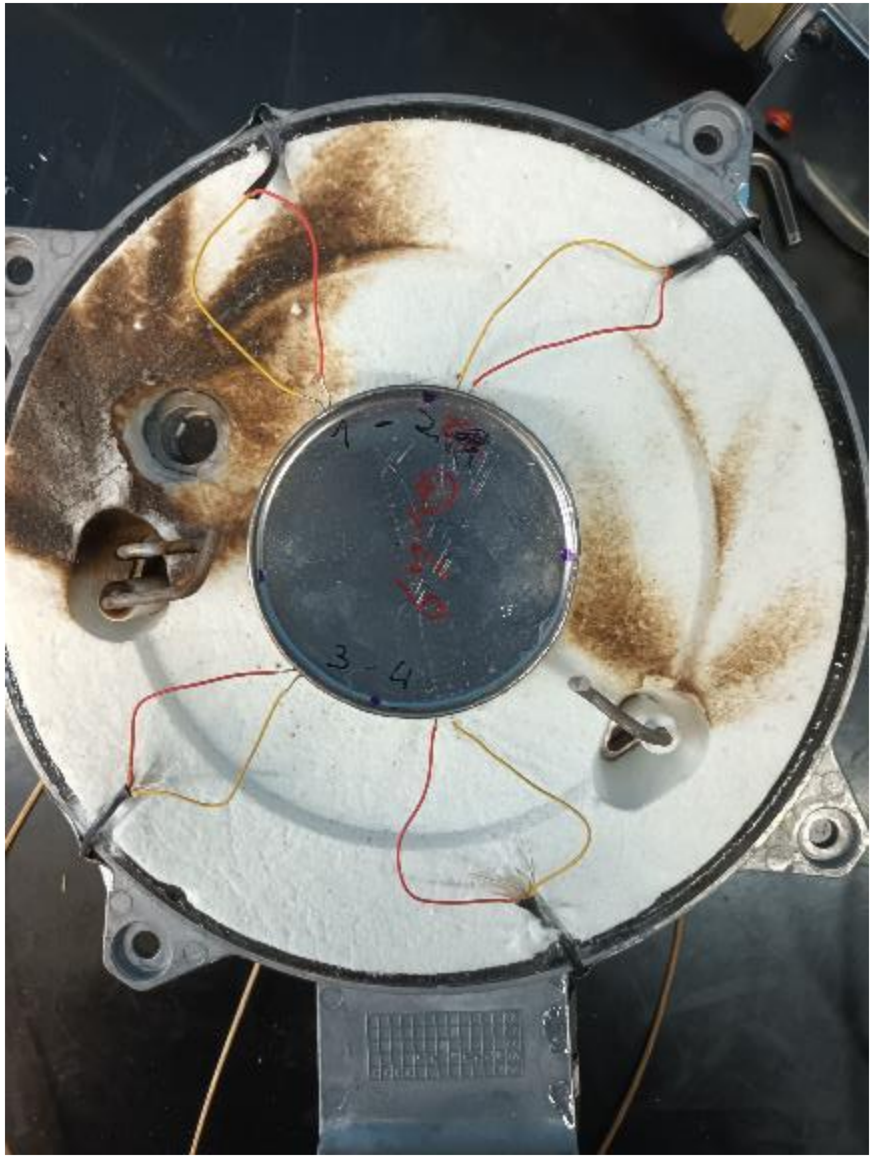
Life test – Endurance tests

Life test H2 burners

Strategy:

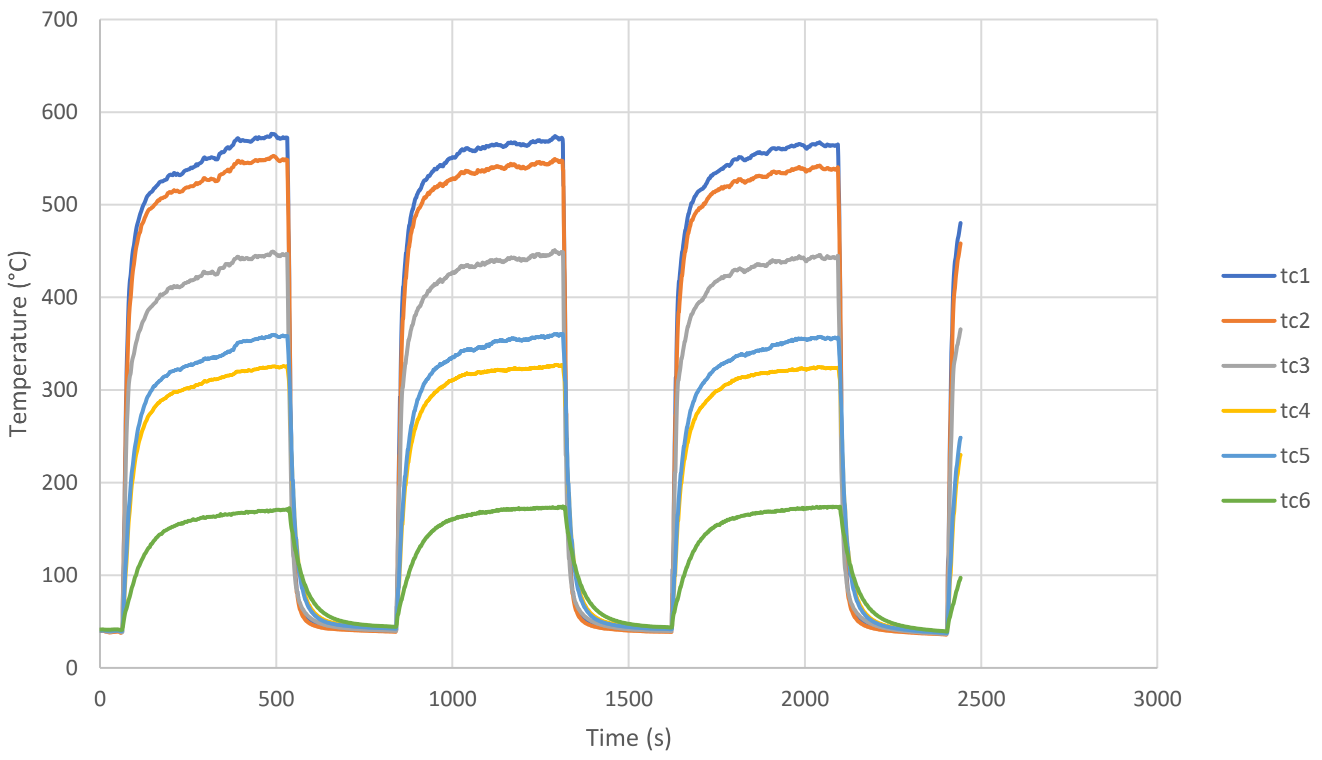
- Measure temperature with H_2, in all the operating conditions
- Determine the equivalent conditions with CH_4
- Life test with CH_4





Work cycles

Example of burner temperature cycles to be used in life testing



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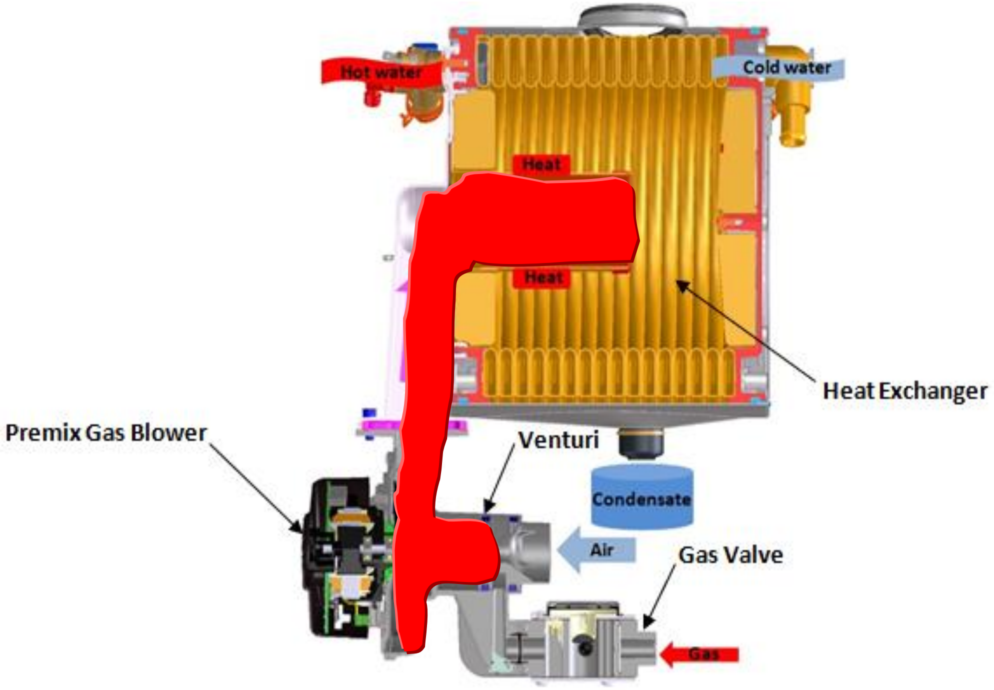
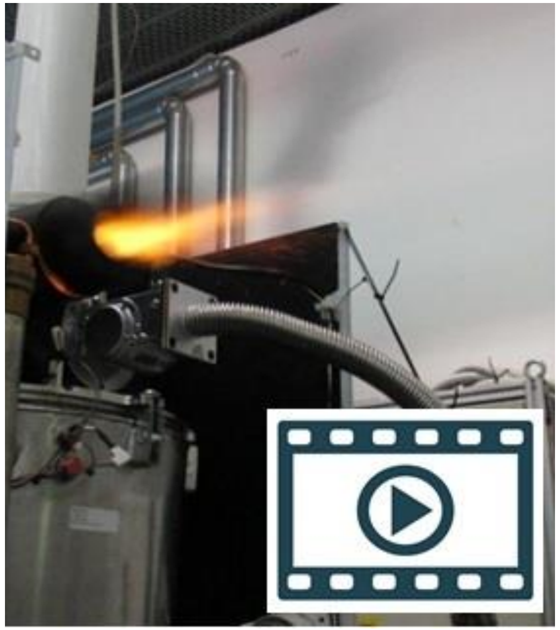
Potential effects of H2 flashbacks

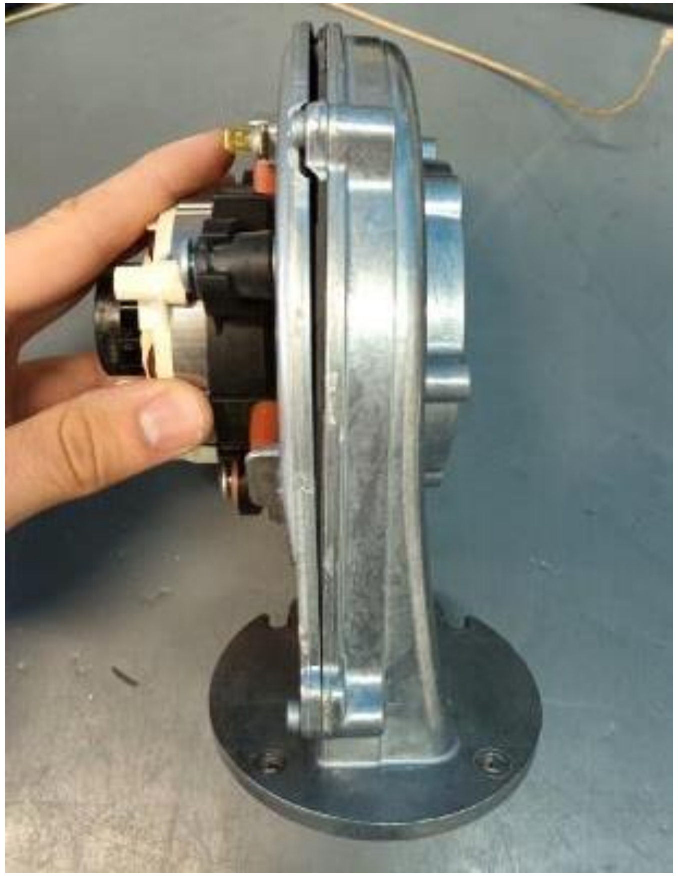
Boiler functionality – Flashback

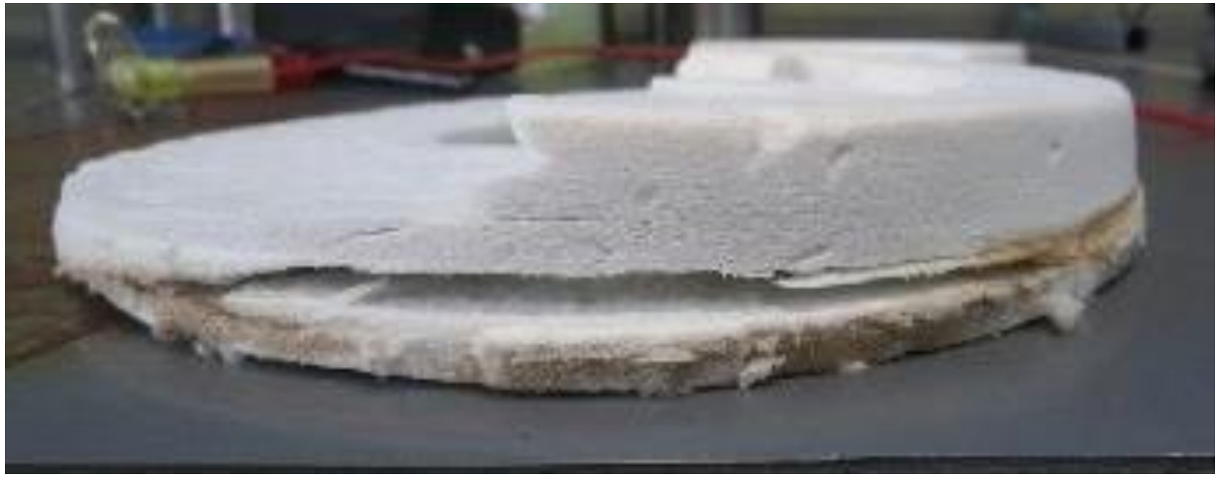
When it happens, the volume of mixture inside the fan, the manifold and the burner ignites.





The results is that the fire can damage plastic parts of the boiler (mixer, fan blades, snorkels and anti-noise foams). The pressure wave can even break some parts.





THANKS!

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