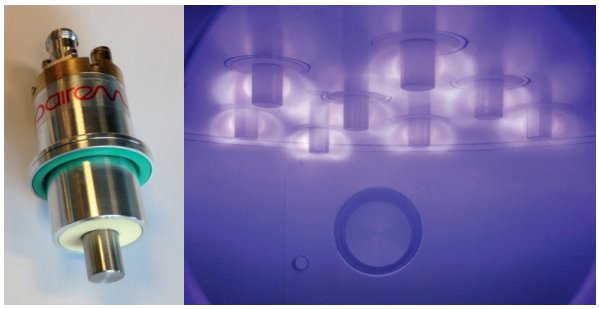
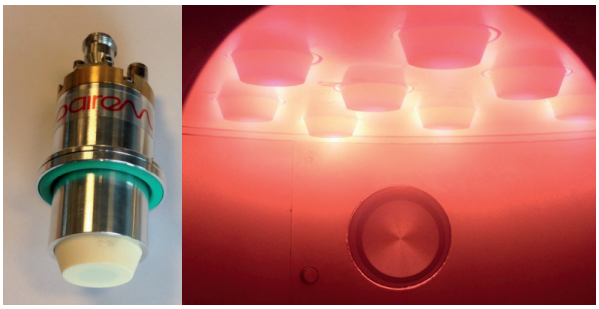
AURA-WAVE & HI-WAVE

COAXIAL PLASMA SOURCES USING SOLID-STATE MICROWAVE TECHNOLOGY

TECHNICAL SPECIFICATION



8 Aura-Wave x 20 W – Argon, 10^{-2} mbar



8 Hi-Wave x 200 W – Nitrogen, 10^{-1} mbar

AURA-WAVE – ECR TYPE

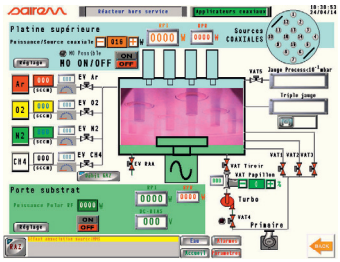
Pressure range	10^{-4} mbar – 10^{-2} mbar
Gas type	Ar, N_2, O_2, CH_4, He, air, ...
Plasma density	> 10^{11} cm^{-3} at 10 cm from sources in multisource configuration
Application type	Creation of radicals, surface activation, PECVD, etching, surface treatment, sterilization via reactive species / UV / ionic bombardment

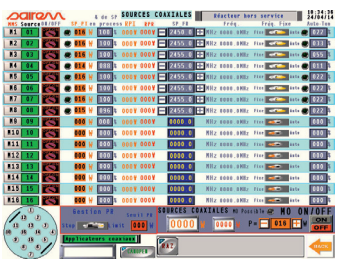
HI-WAVE – COLLISIONAL TYPE

Pressure range	10^{-2} mbar – a few 10^{-1} mbar
Gas type	Ar, O_2, N_2, air, H_2, CH_4...
Plasma density	10^{12} cm^{-3} at 10 cm from sources in multisource configuration
Application type	Creation of radicals, reactive species, PECVD, nanocrystalline diamond, surface treatment e.g. nitruration, cleaning..., etching, sterilization

MULTI-SOURCE CONFIGURATION

Example of integration of 8 plasma sources on a vacuum chamber





KEY POINTS & BENEFITS

- Over dense plasmas, high ion & high active species densities
- Distribution in the desired configuration, matrix, crown, hexagonal, straight line without any limitation in number of sources or dimension
- Matched plasma sources: no impedance tuner required
- Automatic impedance tuning using the variable frequency, SAIREM patent WO 2012/146870: extension of the operating condition range
- Each plasma source is connected to its own microwave generator with output power adjustable from 0 W to 200 W, with 1 W increment
- Possible to control exactly and automatically the transmitted MW power to the plasma whatever the number of plasma sources
- Electrodeless: independent target and substrate bias voltage

CONTACT US

commercial@sairem.com
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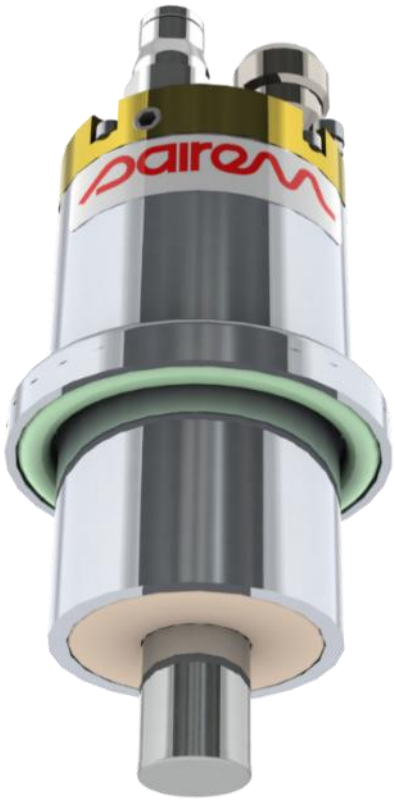
AURA-WAVE
ECR Plasma Source

AURA-WAVE is an ECR coaxial plasma source that has been designed to be self-adapted once the plasma is ignited. A magnetic field combined to the electromagnetic wave allows the creation of plasma at low pressure.



AURA-WAVE is an Electron Cyclotron Resonance (ECR) coaxial plasma source. It has been designed to be self-adapted once the plasma ignited. A magnetic field combined to the electromagnetic wave allows the creation of plasma at low pressure due to Electron Cyclotron Resonance.

AURA-WAVE microwave plasma source has been designed to sustain microwave plasma over several decades of pressure, i.e. **from 10^{-4} mbar to a few 10^{-2} mbar** and from a few watts whatever the gas.

Equally, the coaxial plasma source was designed to avoid inside power-losses and has proved to be matched, i.e. no reflected power with no additional impedance matching system over 2 to 3 pressure decades, depending on the plasma gas. Plasma density up to a few 10^{11} cm^{-3} could be easily obtained in multisource configuration in different gases like argon, oxygen, nitrogen.

When combined with SAIREM solid state microwave generator, it is possible to control the power transmitted to the plasma Watt by Watt. Low mismatching that may appear in the operating conditions can be balanced due to the variable frequency of the solid-state generator and thus permits to extend the operating condition range of AURA-WAVE.

AURA-WAVE is designed to be used equally in R&D laboratories and industry for a very large range of applications. It is ideal for working in the low-pressure range i.e. with high energy particles.

MAIN APPLICATIONS

PLASMA APPLICATION

- PECVD
- Reactive Ion Etching & Deep Etching
- Creation of radicals & reactive species
- ALD
- Surface activation
- Surface treatment: cleaning …
- Sterilization via reactive species / UV / ionic bombardment

82 rue Elisée Reclus
69150 Décines-Charpieu
France
www.sairem.com
welcome@sairem.com
Tel: +33 472 018 160

KEY BENEFITS

DESIGN

- Distribution in the desired configuration: matrix, crown, hexagonal, straight line …
- **No limitation** in the number of sources or plasma dimension
- DN40 KF flange – available in all CF flange
- Electrodeless: independent target and substrate bias voltage
- Possibility to use sapphire protection mask for pollution protection

TECHNOLOGY

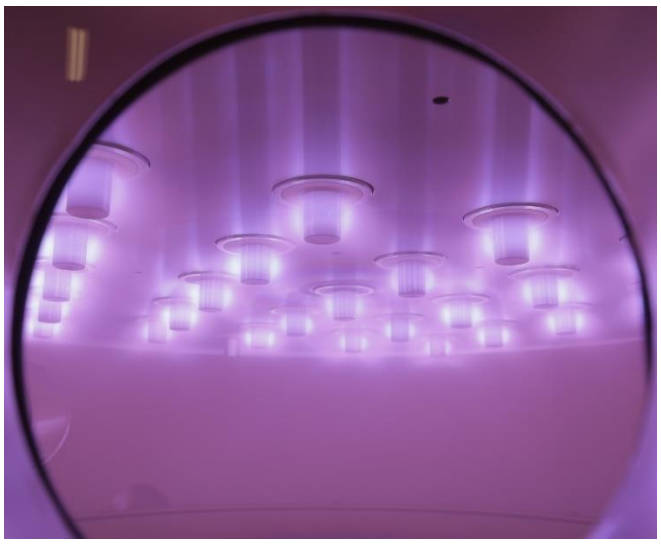
- Matched plasma sources: **no impedance tuner required**[1]
- **Automatic impedance adjustment**[2] using the variable frequency, allowing extension of the operating condition range

CONTROL

- **Automatic control of the transmitted MW power to the plasma** whatever the number of sources
- Each plasma source is connected to its own microwave generator
- Output power adjustable from 0 W to 450 W, with 1 W increment

PERFORMANCES

- **Over dense plasmas**, high ion & high active species densities
- **Uniform plasma** without limitation in terms of areas
- Wide operating condition range: several decades in of pressure (any gas) from a few W to full power



[1] SAIREM patent WO 2017/060611
[2] SAIREM patent WO 2012/146870

AURA-WAVE
ECR Plasma Source

SINGLE SETUP

Solid state generator

Coaxial cable

AURA-WAVE plasma source

MULTIPLE SETUP

The control rack allows to control each AURA-WAVE with 1 W step.

Control Rack

Control screen

AURA-WAVE plasma sources

4 off × 200 W 2.45 GHz module rack
or
4 off × 450 W 2.45 GHz module rack

AURA-WAVE
ECR Plasma Source

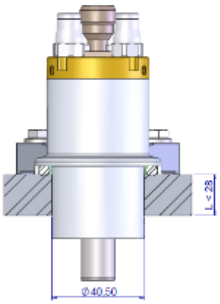
KEY SPECIFICATIONS

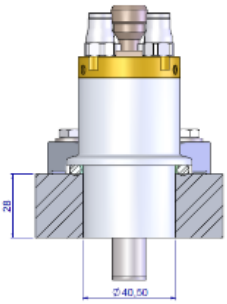
REFERENCE	• CPSKFDN40ECR2DP A
Frequency	• 2400 – 2500 MHz • 0.1 MHz increment
Microwave power	• Max. 450 W
Working pressure range	• A few 10^{-4} mbar to a few 10^{-2} mbar

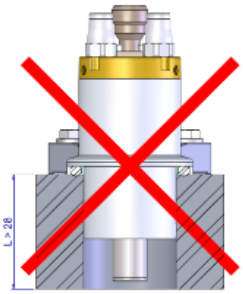
Plasma density * (measured in Ar-O_2-N_2)	• Single source:
	  ○ 3-8 × 10^{10} cm^{-3} at 150 mm
	  ○ 8 x 10^{10} to > 10^{11} at 100 mm
	• Multisource:
	  ○ 5-10^{10} to a few 10^{11} at 150 mm
	  ○ 10^{11} to 5 x 10^{11} cm^{-3} at 100 mm

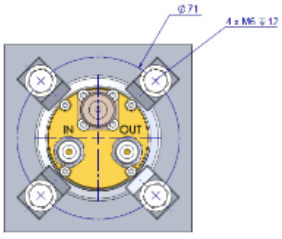
Connections	• DN40 KF flange – available in all CF flange on request
Cooling by water	• Push-fit connectors for OD 6 mm tubing • Water-cooling of the sources is mandatory (at least 1 l/min)

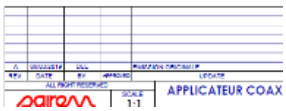
INSTALLATION





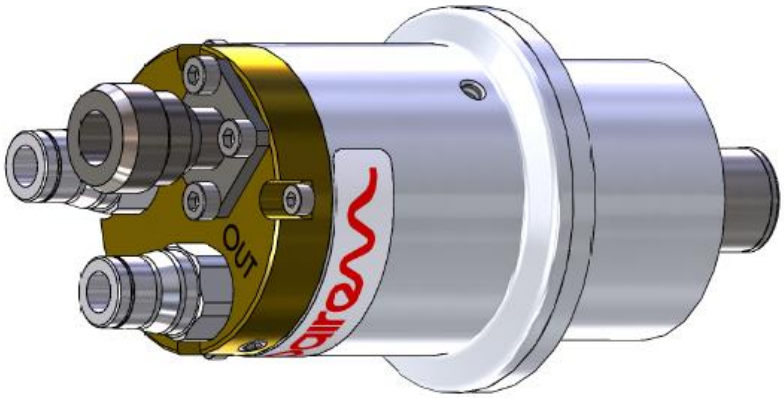


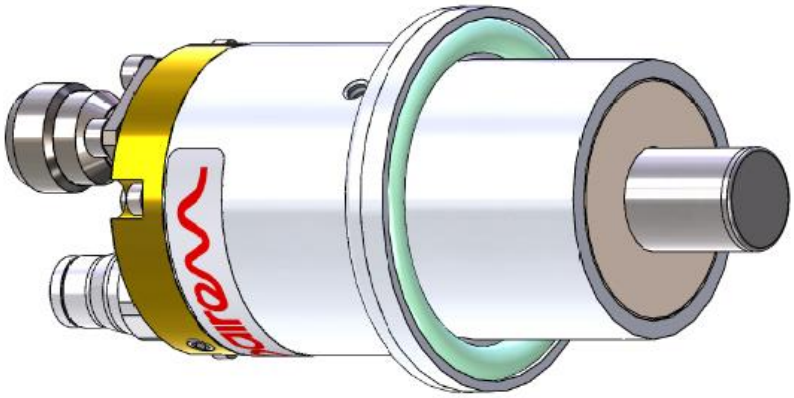


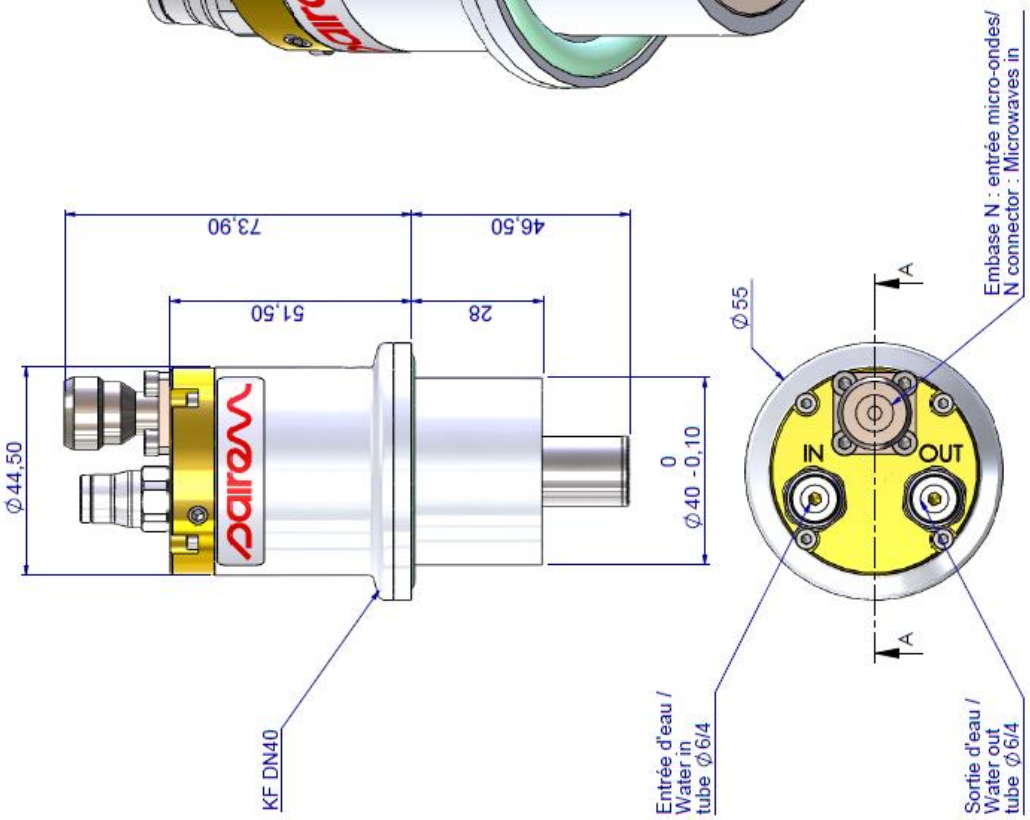


« * at 400 W/source, optimal pressure »

MAIN DIMENSIONS







82 rue Elisée Reclus
69150 Décines-Charpieu
France
www.sairem.com
welcome@sairem.com
Tel: +33 472 018 160

HI-WAVE
Collisional Plasma Source

HI-WAVE microwave collisional plasma source has been designed to sustain microwave plasma from 10^{-2} mbar to a few 10^{-1} mbar and from a few watts microwave power, whatever the gas.

HI-WAVE collisional coaxial plasma source was designed to avoid inside power-losses and has proved to be matched, i.e. no reflected power with no additional impedance matching system over 1 pressure decade, depending on the plasma gas. Moreover, plasma density higher than **10^{12} cm^{-3}** could be easily obtained in multisource configuration at a few cm from the sources.

When combined with our solid-state microwave generator, it is possible to control the power transmitted to the plasma Watt by Watt. Low mismatching that may appear in the operating conditions can be balanced due to the variable frequency of the solid-state generator and thus permits to extend the operating condition range of the HI-WAVE.

HI-WAVE is designed to be used equally in R&D laboratories and industry for a very large range of applications.

MAIN APPLICATIONS

PLASMA APPLICATION

- Reactive Ion Etching & Deep Etching
- PECVD
- Creation of radicals & reactive species
- ALD
- Nanocrystalline diamond
- Surface treatment: nitriding…
- Sterilization via reactive species / UV / ionic bombardment

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KEY BENEFITS

DESIGN

- Distribution in the desired configuration, matrix, crown, hexagonal, straight line
- **No limitation** in the number of sources or dimension
- DN40 KF flange – available in all CF flange
- Electrodeless: independent target and substrate bias voltage

TECHNOLOGY

- Matched plasma sources: **no impedance tuner required**[1]
- **Automatic impedance adjustment**[2] using the variable frequency, allowing extension of the operating condition range

CONTROL

- **Automatic control on the transmitted MW power to the plasma** whatever the number of sources
- Each plasma source is connected to its own microwave generator
- Output power adjustable from 0 W to 450 W, with 1 W increment

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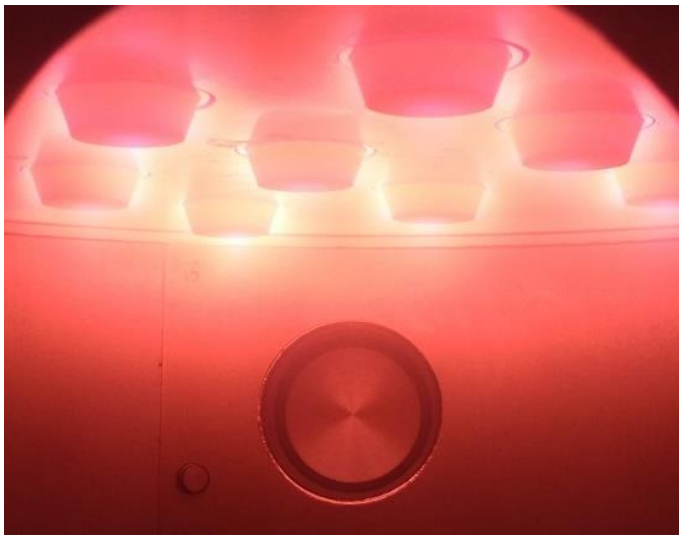
- Wide operating condition range: several decades in pressure (any gas) from a few W to full power



[1] SAIREM patents WO 2017/060611 & WO 2017/060612
[2] SAIREM patent WO 2012/146870

HI-WAVE
Collisional Plasma Source

SINGLE SETUP

Solid state generator

HI-WAVE plasma source

Coaxial cable

MULTIPLE SETUP

The control rack allows to control each HI-WAVE with 1 W step.

Control Rack

Control screen

HI-WAVE plasma sources

4 off × 200 W 2.45 GHz module rack
or
4 off × 450 W 2.45 GHz module rack

HI-WAVE
Collisional Plasma Source

KEY SPECIFICATIONS

REFERENCE	• CPSKFDN40ECR2DP A
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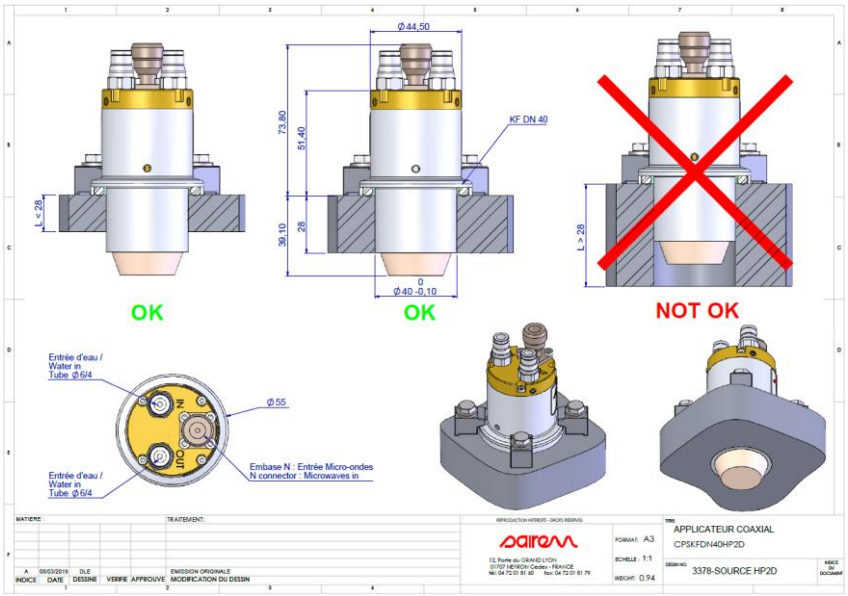
Working pressure range	• 10^{-2} mbar to a few 10^{-1} mbar

Plasma density * (measured in Ar-O_2-N_2)	• Single source:
	  ○ 1 to 7 × 10^{11} cm^{-3} at 150 mm
	  ○ 3 x 10^{11} cm^{-3} to 3 × 10^{12} cm^{-3} at 100 mm
	• Multisource:
	  ○ a few 10^{11} cm^{-3} to a few 10^{12} cm^{-3} at 150 mm
	  ○ 10^{12} cm^{-3} up to 10^{13} cm^{-3} at 100 mm

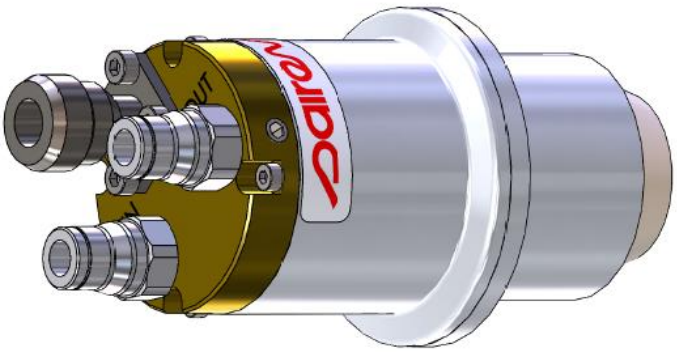
Connections	• DN40 KF flange – available in all CF flange on request
Cooling by water	• Push-fit connectors for OD 6 mm tubing. • Water-cooling of the sources is mandatory (at least 1 l/min).

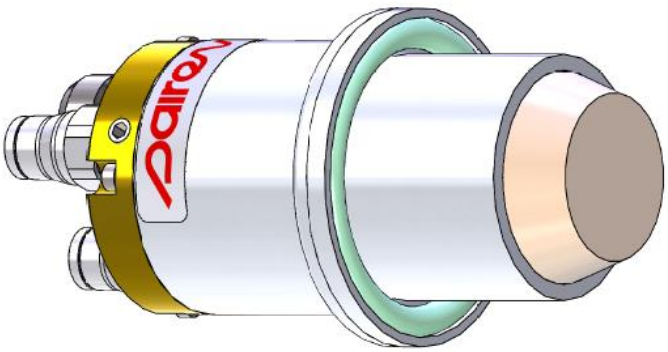
INSTALLATION

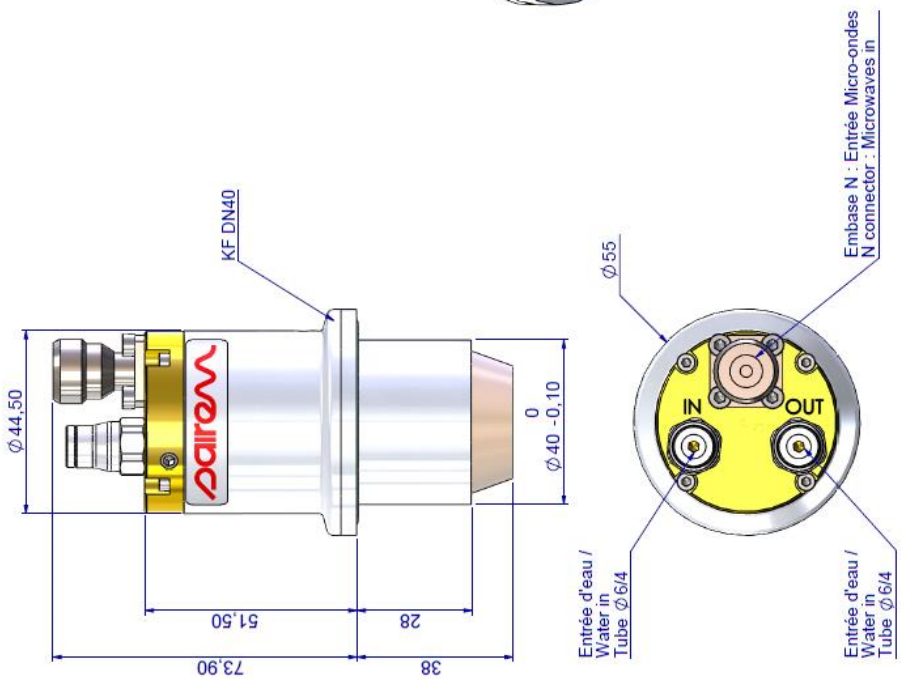


« * at 400 W/source, optimal pressure »

MAIN DIMENSIONS







Microwave coaxial plasma sources: design and performances

Microwave plasma for low pressure surface treatment using solid state technology

Today, uniform plasma processing over large dimensions, and most often requiring strong ionic assistance, are essential for surface treatments at industrial level which require higher etching or deposition rates, such as **PECVD** (Plasma Enhanced Chemical Vapor Deposition) or **deep etching**. These requirements have stimulated the development of uniform plasma sources, of high density, and moreover capable of delivering **high concentrations of reactive species**.

Microwave plasma sources are well known for their performance in terms of creating high densities of species, but have often been considered a second choice given the difficulty of implementing them in an industrial process. For example, such sources often require an impedance adaptation system that is difficult to automate. In addition, to create a large volume of plasma by overcoming the critical density limiting the propagation of waves, it is necessary to wisely distribute the plasma sources, thus adding a strong constraint on the control of the power transmitted to each source.

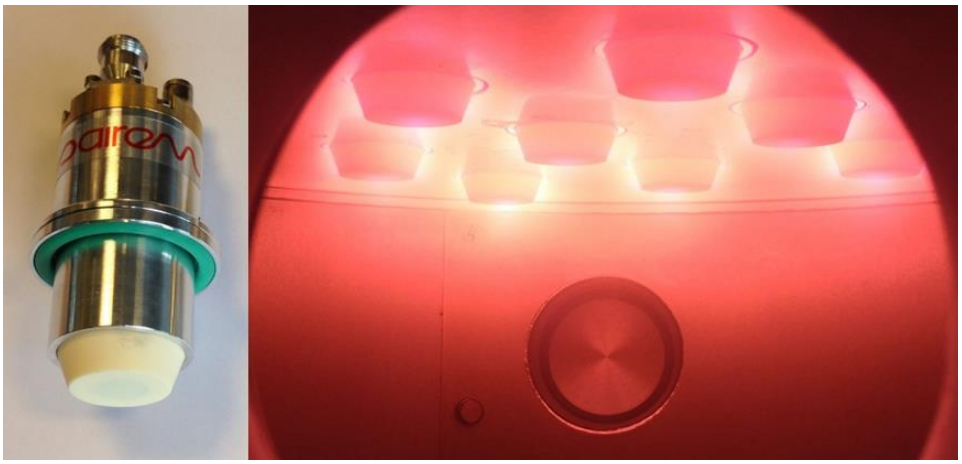
To overcome these constraints, SAIREM has developed two types of innovative microwave plasma sources operating with solid state generators:

Self-matching plasma sources using 2.45 GHz solid state generators

- **Aura-Wave** is an **ECR** (Electronic Cyclotron Resonance) microwave coaxial plasma source which can sustain stable plasmas from **a few 10^{-4} to 10^{-1} mbar** (a few 10^{-2} Pa to a 10 Pa) depending on gas nature (see details in section “Recommendations”). Permanent cylindrical magnets are encapsulated and mounted in opposition inside the coaxial structure [1], allowing the generation of a magnetic field towards the plasma chamber in order to limit losses to the walls. The source makes it possible to reach plasma densities of **a few 10^{11} cm^{-3}** in multisource configuration at 10 cm from the sources plane.

Aura-Wave ECR coaxial plasma source; 25 x 400 W (10 kW), oxygen, 1 Pa

- **Hi-Wave** is a collisional type microwave plasma source operating from a few **10^{-2} to 1 mbar** (a few Pa to 100 Pa). It is thus intended to operate without magnets in the collisional regime. Plasma densities **greater than 10^{12} cm^{-3}** can be achieved in multisource configuration at 10 cm from the sources plane.



Hi-Wave coaxial plasma source; 8 × 200 W, nitrogen, 10 Pa.

Both sources have been designed to avoid internal power losses and to be used **without** the need for **any impedance matching system** over the entire operating range of each plasma source [2-4]. The sources are said to be **self-adapted**. To do this, a long microwave modeling step was performed, the principle was to avoid any abrupt impedance change inside the source. Also, the shape of the dielectric allowing the transmission of waves in the plasma chamber has been carefully modeled to favor the penetration of microwaves into the plasma. Thus, **each plasma source is linked directly by a simple coaxial cable to its own solid-state generator** with adjustable power between 0 and 450 W and tunable frequency from 2.4 to 2.5 GHz. The adjustable frequency of the generator is intended to be used as backup matching means if the reflected power increases above a set value; an automatic adjustment loop enables the microwave generator to start sweeping the frequency band until the lowest reflected power level is found [2].

Patents

[1] S Béchu, A Bès, A Lacoste, J Pelletier, Device and method for producing and/or confining a plasma, Patent WO 2010/049456.

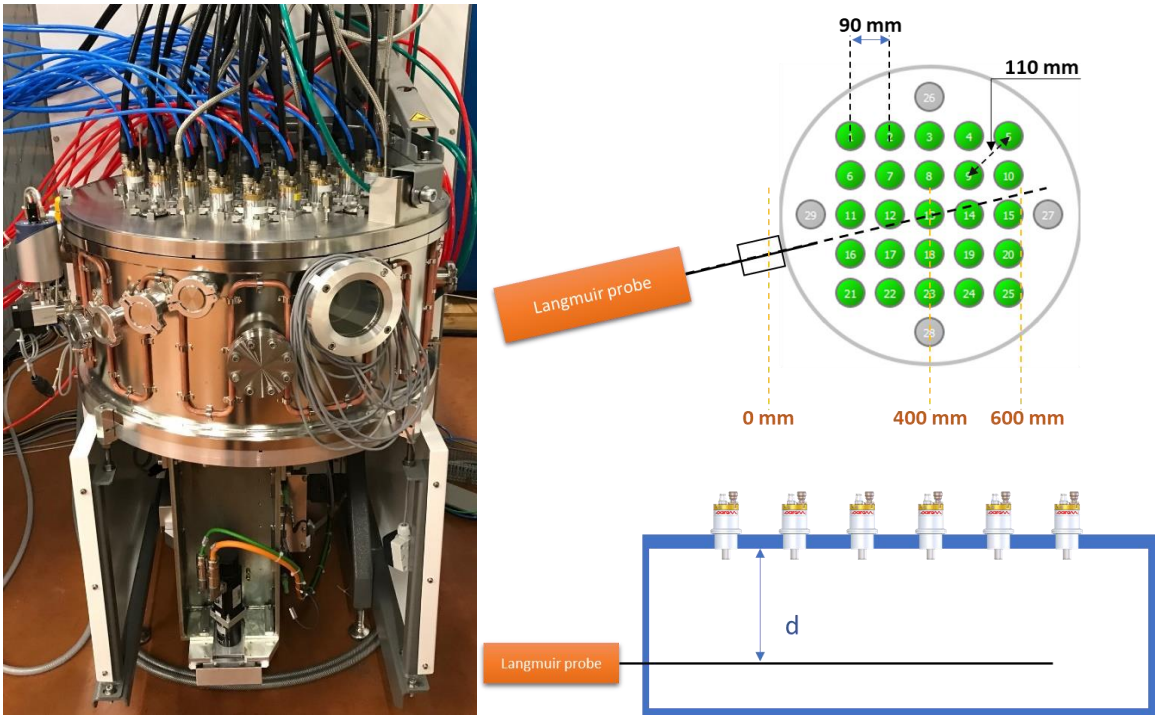
[2] A Grandemenge, J-M Jacomino, L Latrasse, M Radoiu, Facility for microwave treatment of a load, Patent WO 2012/146870.

[3] L Latrasse, M Radoiu, Elementary device for applying a microwave energy with coaxial applicator, Patent WO 2017/060611.

[4] L Latrasse, M Radoiu, Elementary device for producing a plasma, having a coaxial applicator, Patent WO 2017/060612.

Surface treatment over large dimensions with Aura-Wave

Concerning surface treatment over large areas, the sources could be distributed in different configurations, as in matrix, circular, or circular centered configurations for example. Below are examples of some measurements tested on a demonstrator located at SAIREM. This demonstrator, presented in the figure below, allows to integrate up to 25 sources distributed in matrix configuration with a lattice mesh a= 90 mm (i.e. the distance between 2 sources). Plasma density measurements were performed using a Langmuir probe including a translation system, the density profiles were measured at a fixed distance from the sources plane d (10 and 14 cm in examples presented here), as shown in the figure below, right.



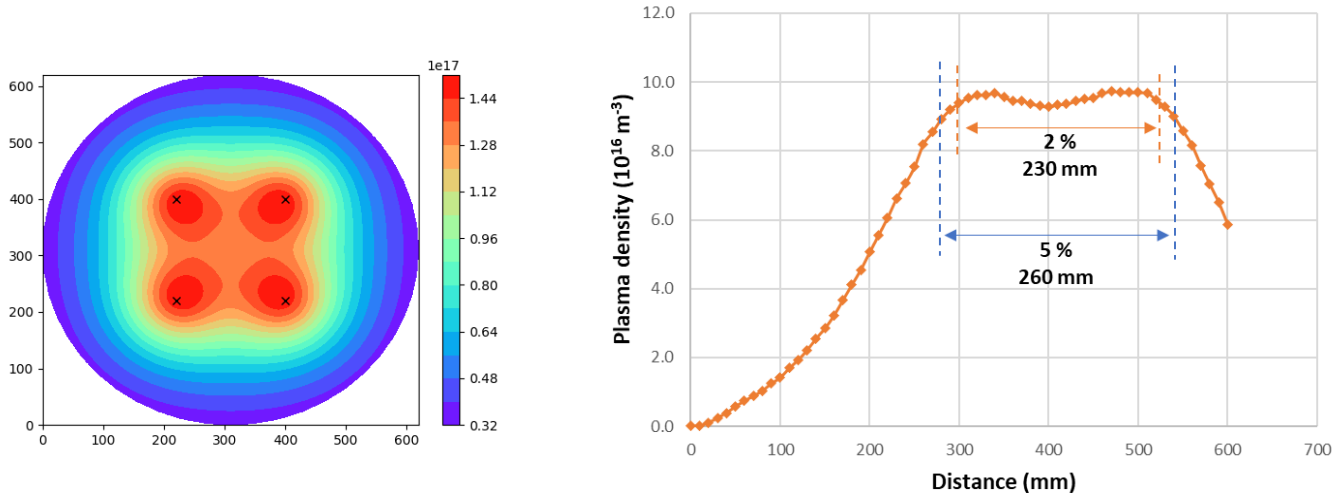
Left: demonstrator for large surface treatment. Right: Sketch representing density profiles measurement setup.

Previous plasma measurements have shown that the radial density profile of several plasma sources measured at a fixed distance from the source plane corresponds to the algebraic sum of all the density profiles obtained for each source individually. Thus, the profile obtained for a single source could be used to extrapolate the density profiles for an unlimited number of plasma sources. Thanks to this result, a simulation software was developed, which is very helpful to predict a distribution as a function of the specification of the customer (number of sources i.e. budget, distance to the substrate holder, gas nature, working pressure, requested plasma density, treatment surface…).

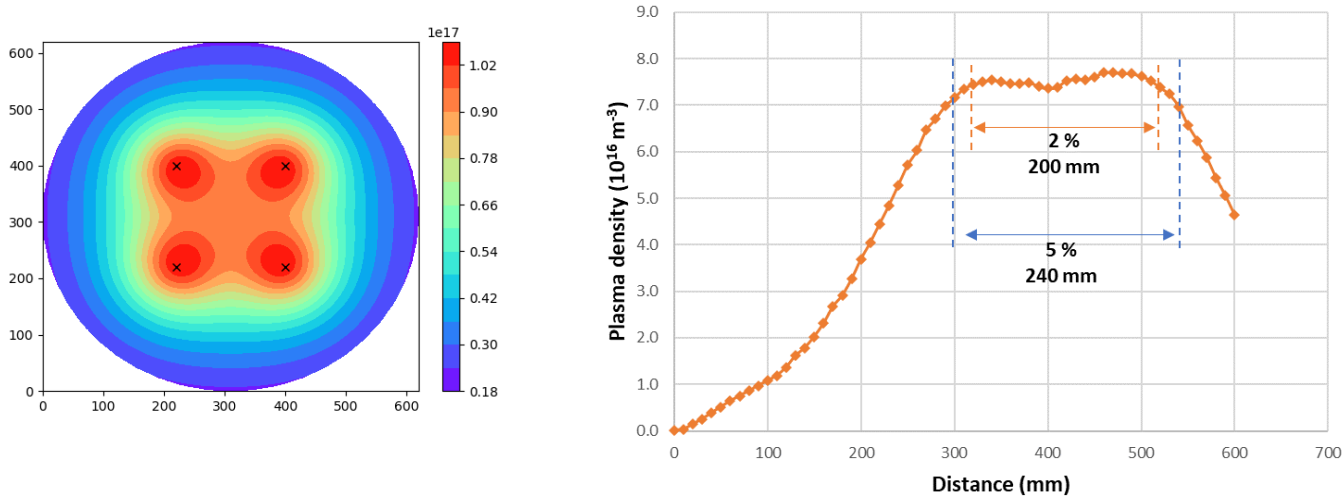
This software showed very satisfying coherence with experimental results.

4 plasma sources in matrix configuration

Figure below, left, represents the plasma density calculated for a plasma sustained by 4 Aura-Wave in matrix configuration with a lattice mesh a= 180 mm and at a distance from the source plane d = 10 cm. Plasma operating conditions are N_2 at 1 Pa and 400 W per plasma source. Figure on the right shows the corresponding measurement in the demonstrator. The simulation is a top view map and the measurement was performed in one dimension but could be assume to be quite symmetric in revolution, i.e. whatever the Langmuir probe position around the plasma chamber.



Distribution of the plasma density, matrix configuration, 4 sources a = 180 mm, d = 10 cm, N_2, 1 Pa, 400 W/source. Left: simulation. Right: measurement.

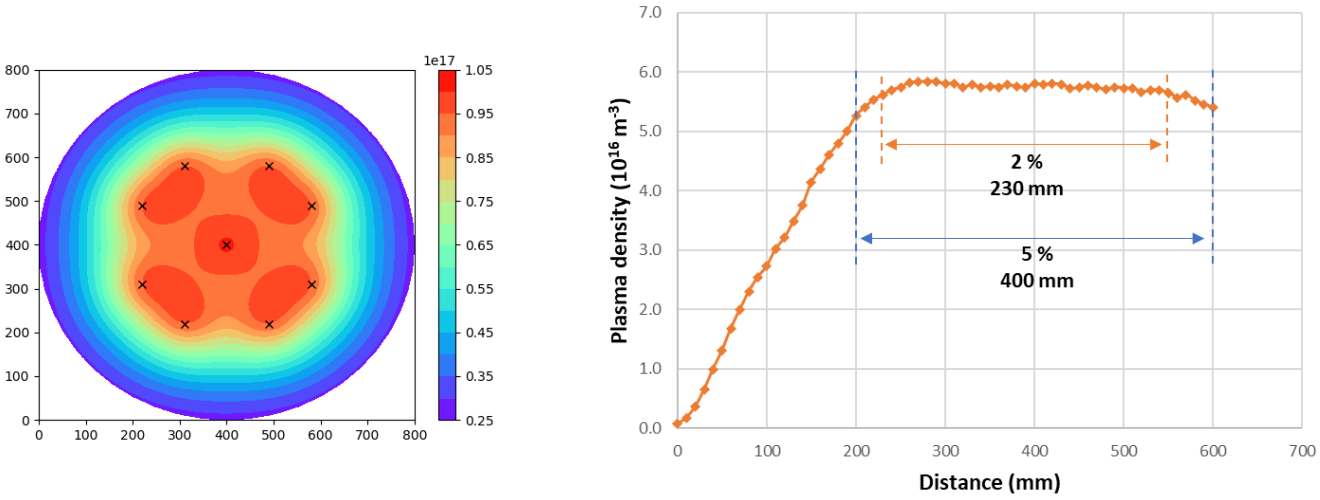


Distribution of the plasma density, matrix configuration, 4 sources, a = 180 mm, d = 10 cm, O_2, 1 Pa, 400 W/source. Left: simulation. Right: measurement.

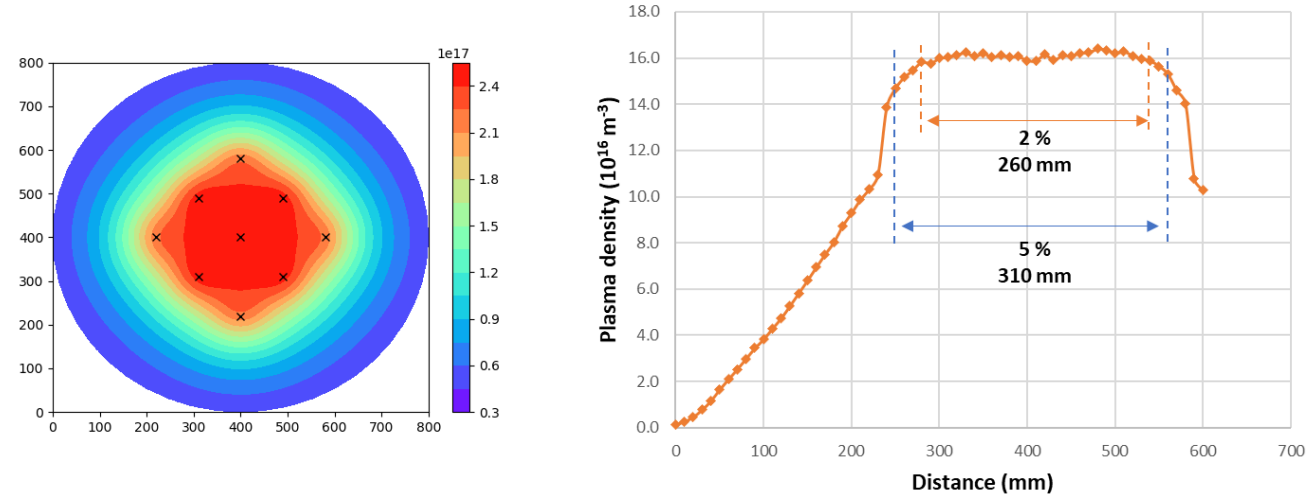
The same simulation and measurement were performed in O_2, as shown above. In both cases, a good correlation is observed and 4 plasma sources allow to generate a very uniform and dense plasma. A uniformity of 2 % is obtained over a diameter of 200 mm and 5 % around 250 mm. The plasma density reaches around 10^{11} cm^{-3}.

9 plasma sources

Figure below, left, represents the plasma density calculated for a plasma sustained by 9 Aura-Wave in circular centered configuration on a diameter around 400 mm and at a distance from the source plane d = 14 cm. Plasma operating conditions are N_2 at 1.5 Pa and 400 W per plasma source except for the centered one which has half the power. Figure on the right shows the corresponding measurement in the demonstrator.



Distribution of the plasma density, circular centered configuration with 9 sources on a diameter of 400 mm, d = 14 cm, N_2, 1.5 Pa, 400 W/source and 200 W for the centered one.
Left: simulation. Right: measurement.



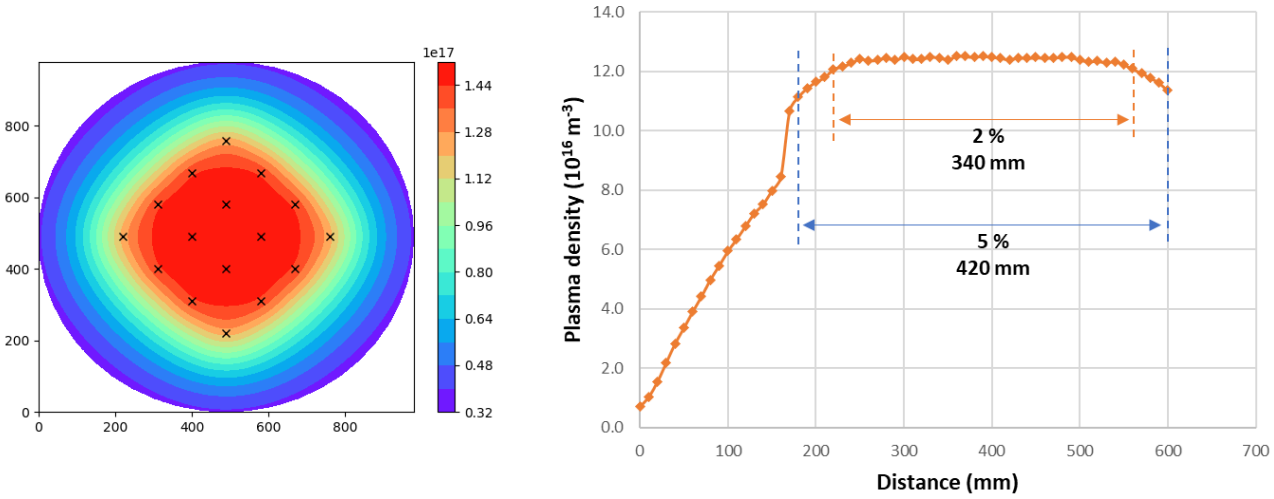
Distribution of the plasma density in matrix configuration, 9 sources, a = 110 mm, d = 10 cm, N_2, 1 Pa, 400 W/source, 100 W for the central one. Left: simulation. Right: measurement.

Simulation and measurement with 9 plasma sources distributed in matrix configuration with a lattice mesh a = 110 mm is represented above. Operating conditions are N_2 at 1 Pa and 400 W per source (except the central sources).

Results show that with 9 sources it is possible to be uniform on 400 mm with 5 % of uniformity, using a circular centered configuration. A matrix configuration with a = 110 mm is more compact and allow to work closer to the source plane, it reduces the uniformity diameter to around 300 mm with a uniformity of 5 % but increases the plasma density by a factor of 3.

16 plasma sources distributed in matrix configuration

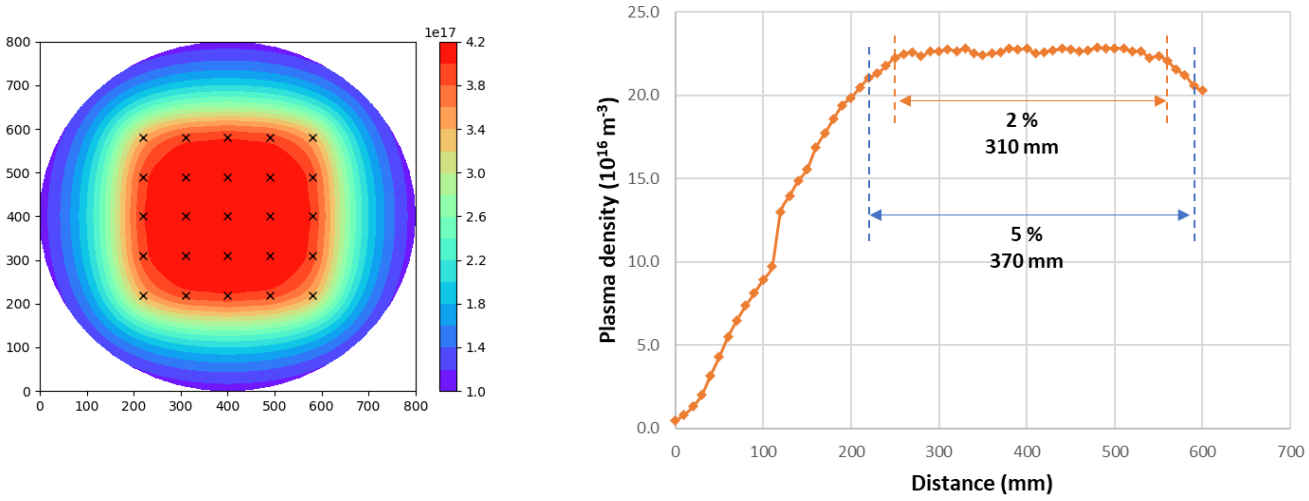
Figure below, left, represents the plasma density calculated for a plasma sustained by 16 Aura-Wave in matrix configuration with a lattice mesh a = 110 mm at a distance from the source plane d = 10 cm. Plasma operating conditions are Ar at 0.1 Pa and 400 W per plasma source on the peripherical sources and 50 W in the 4 central ones. Figure on the right shows the corresponding measurement in the plasma chamber.



Distribution of the plasma density, matrix configuration, 16 sources, a = 110 mm, d = 10 cm, Ar, 0.1 Pa, 400 W/source for the peripherical sources, 50 W for the 4 central ones.
Left: simulation. Right: measurement.

This configuration allows to obtain high density with a uniformity of 5 % on 420 mm in diameter.

25 plasma sources distributed in matrix configuration



Distribution of the plasma density, matrix configuration, 25 sources, a = 90 mm, d = 10 cm, N_2, 1 Pa, 400 W/source for the peripherical sources, 100 W for the 9 central ones.
Left: simulation. Right: measurement.

Figure above, left, represents the plasma density calculated for a plasma sustained by 25 Aura-Wave in matrix configuration with a lattice mesh a= 90 mm and at a distance from the source plane d = 10 cm. Plasma operating conditions are N_2 at 1 Pa and 400 W per plasma source on the peripherical sources and 100 W in the 9 central ones. Figure on the right show the corresponding measurement in the plasma chamber.

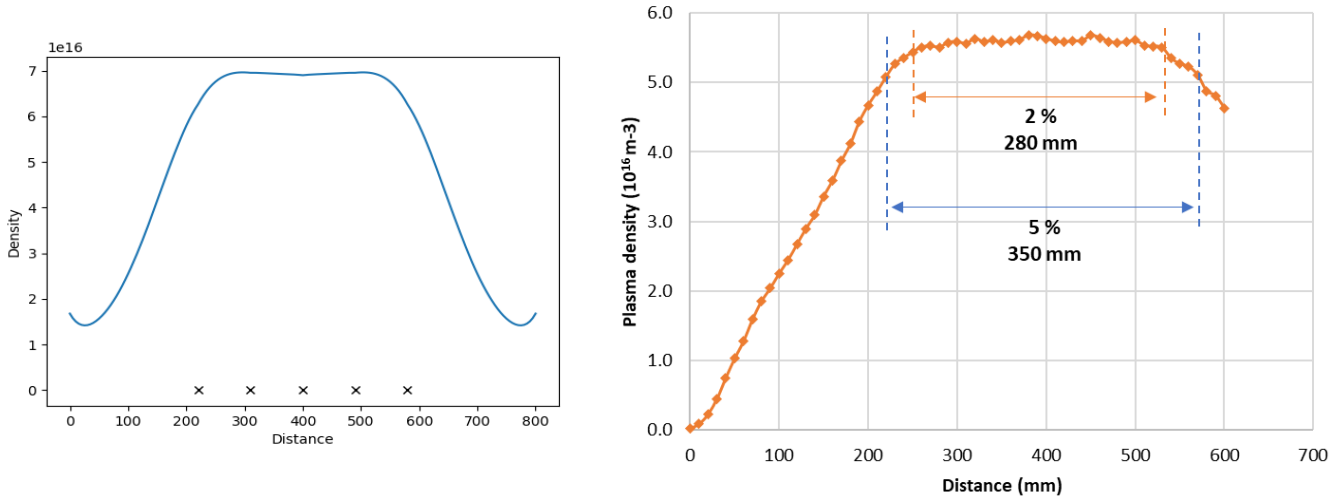
This configuration allows to obtain very high density with a uniformity of 5 % on 370 mm in diameter and 2 % on 310 mm.

Conclusion on large area treatment

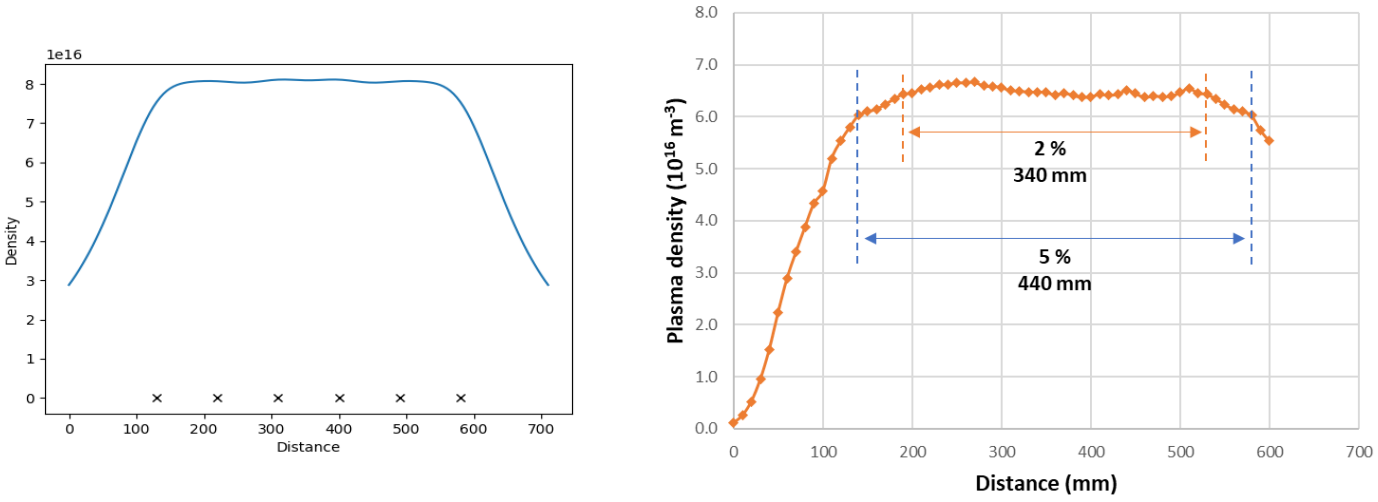
It is possible to create uniform plasma with a reduced number of plasma sources. 4 plasma sources allow to be uniform on more than 200 mm, 9 plasma sources for 300 to 400 mm, 16 for more than 400 mm. Roughly, the maximum distance between the peripherical sources allows to cover the same area, but the lattice mesh should not exceed 220 mm. Increasing the number of plasma sources while keeping the distance between the peripherical sources, i.e. increasing the compactness, allows to work closer to the source plane. Both the compactness and the shorter distance help to increase a lot the plasma density and thus to achieve very high reactive species density essential for plasma processes such as CVD, Reactive Ion Etching, deep etching, or functionalization….

Linear treatment over large length

Other measurements were performed in linear configuration. Figures below show, on the left, the plasma density calculated for a plasma sustained by 5 Aura-Wave in linear configuration with a distance between sources b = 90 mm and at a distance from the source plane d = 14 cm. Plasma operating conditions are N2 at 1 Pa and 400 W per plasma source on the edge sources and half the power in the 3 central ones. On the right, the corresponding measurement in the plasma chamber.



Distribution of the plasma density, linear configuration, 5 sources, b = 90 mm, d = 14 cm, N_2, 1 Pa, 400 W/source for the edge sources, 200 W for the 3 central ones.
Left: simulation. Right: measurement.



Distribution of the plasma density, linear configuration, 6 sources, b = 90 mm, d = 14 cm, N_2, 1 Pa, 400 W/source for the edge sources, 200 W for the 4 central ones. Left: simulation. Right: measurement.

Figures above show, on the left, the plasma density calculated for a plasma sustained by 6 Aura-Wave in linear configuration with a distance between sources b = 90 mm and at a distance from the source plane d = 14 cm. Plasma operating conditions are N_2 at 1 Pa and 400 W per plasma source on the edge sources and half the power for the 4 central ones. Figure on the right shows the corresponding measurement in the plasma chamber.

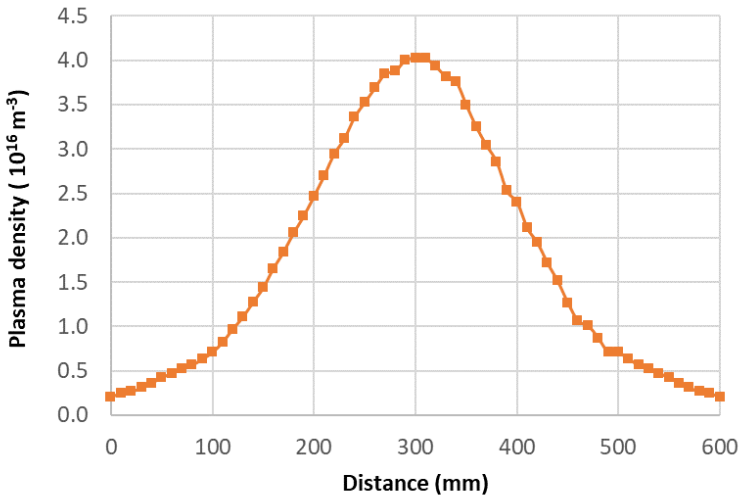
Correlation between measurements and simulation is quite satisfying. 5 plasma sources allow to be uniform with 5 % uniformity on 350 mm and 6 plasma sources on 440 mm. As for area treatment, the distance between the edge sources allows to cover the same distance, roughly, as b = 90 mm, adding a plasma source allows to increase uniformity on additional 90 mm.

Other measurements and simulation were performed with larger distance b, less compactness allows to cover higher length but decreases the plasma density.

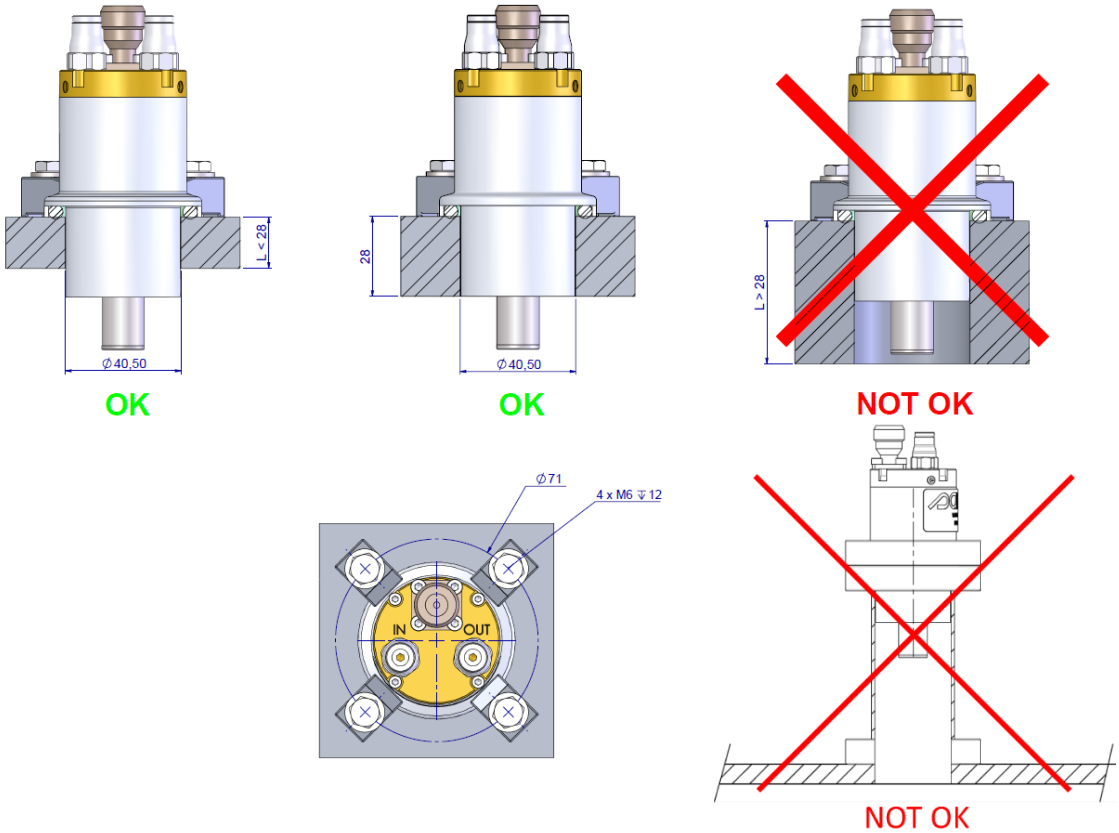
Recommendations and advices

Implementation

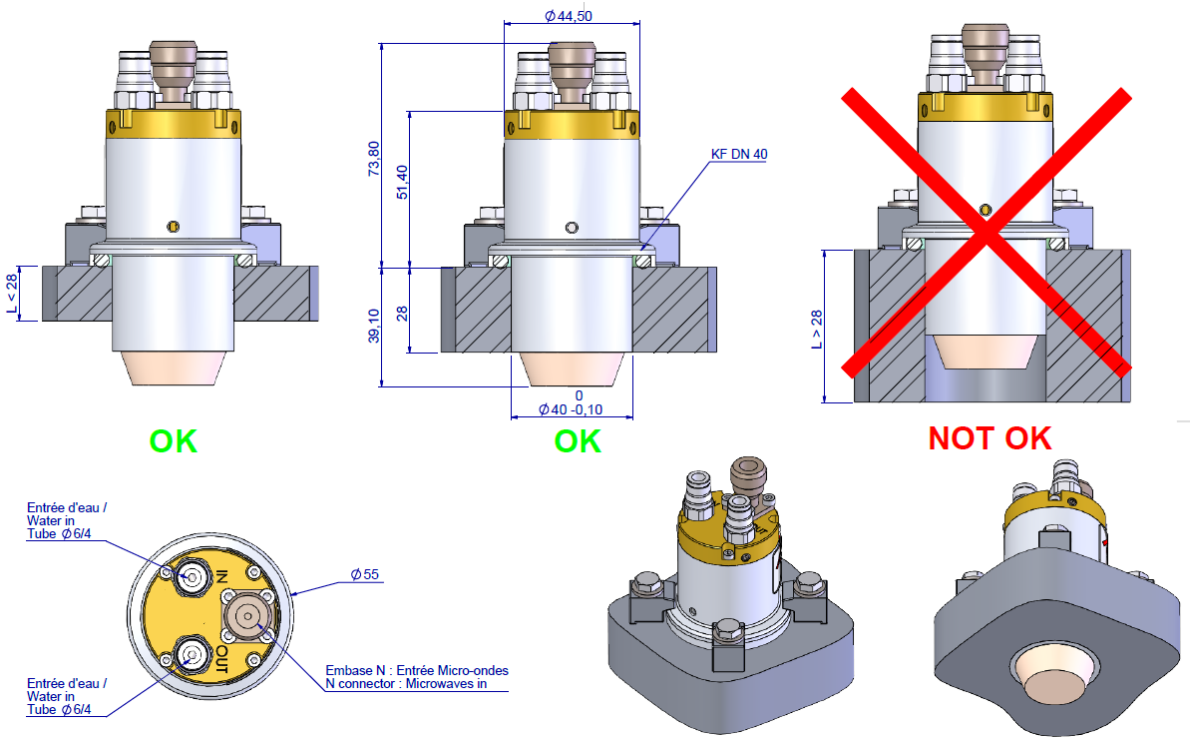
The plasma sources spread a lot; it means that the ion production volume is quite large. An example of plasma density measured by one plasma source at a distance from the source plane d = 14 cm is presented below for pure N_2 at 1 Pa and 400 W. In this case, on 250 mm in diameter (125 mm from the center), the plasma density drops only by 50 %. At lower pressure, diffusion is higher so this diameter is increased.



Density profile measured for one Aura-Wave at d = 14 cm, N_2 – 400 W.



Implementation of the Aura-Wave plasma source.



Implementation of the Hi-Wave plasma source.

Consequently, if the chamber is too small or if the source is confined in a connection flange or a wall (see implementation figures of Aura-Wave and Hi-Wave above), edge effect will appear leading to a quick drop of the density on the wall, creation of reflected power, and an increase of pollution due to wall sputtering. For this reason, we recommend to implement the source at least 150 mm from the wall, i.e., for a single source integration, i.e. in a plasma chamber at least 300 mm in diameter.

Operating pressure depending on the source type and the gas nature

Operating pressure ranges are presented below for both Aura-Wave and Hi-Wave as a function of the gas nature.

Source type	Gas	Operating pressure range (Pa)
Aura-Wave	H_2, He	0.1 to a few 10s Pa
	O_2, N_2	10^{-2} to a few Pa
	Ar	10^{-2} up to 1 Pa
Hi-Wave	H_2	10 to 100 Pa
	O_2, N_2	A few 10^{-2} to a few 10s Pa
	Ar	A few 10^{-2} to a few Pa

These pressure ranges could vary with measurement gauges and also with number and compactness of the plasma sources in multisource configuration.

Concerning Aura-Wave, from a general point of view, when the pressure is too high the plasma loose its “Aura shape” or “donuts shape” due to magnetic confinement and the plasma start to stick to the

alumina. The ECR heating is not any more efficient. The plasma becomes dense, not confined and it leads to an increase of the reflected power (the plasma acts as a sheet of metal).

From a general point of view, whatever the source used, a consequent reflected power increase (5-10 % after frequency scan) means that the source is working in its upper pressure limit.

Water cooling and microwave connections

It is mandatory to cool the plasma sources during processes. At least 1 l/min is necessary to cool each source. Quick connectors for 6 mm OD tubing IN and OUT are implemented on the rear of the source. The flow direction of water should be respected.

The coaxial cable should be well screwed on the N connectors of both the microwave module and the plasma source to prevent arcing.

Scan frequency

After plasma ignition, always perform a frequency scan to decrease reflected power.

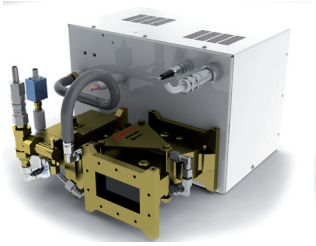
Hi-Wave particularity

The Hi-Wave is more efficient than the Aura-Wave in terms of performance (plasma density and reactive species production) as it works at higher pressure. Nevertheless, it is also more delicate to use, indeed collisional heating is less efficient than ECR, and it operates on a shorter pressure window because the plasma is created directly in contact with the alumina (leading to high variation of impedance with pressure). Consequently, it is more difficult to ignite and sustain the plasma. Thus, we strongly recommend not to use the Hi-Wave in single set up. The Hi Wave should be used in a setup of, at least, four sources with their corresponding microwave modules.

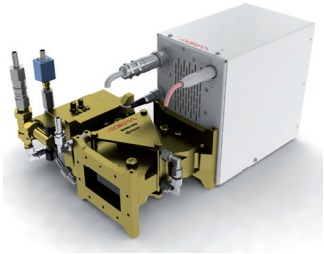
2.45 GHz MICROWAVE GENERATORS
(GENERATION 3)

The new G3 power supply design is based upon the latest switch mode power supply technology, offering small footprint (19" rack 3U), good power stability and significantly reduced electrical losses. The efficiency of the switch mode power supply is > 93 %.

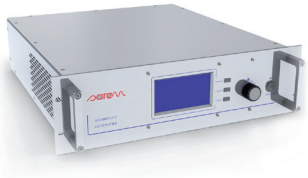
Build the generator that best respond to your application requirements thanks to a large choice in option:



6 kW Microwave Head and Isolator



2, 3 kW Microwave Head and Isolator



2.45 GHz Switch mode power supply

GMP	xxK	xx	56xxxx	xxx	x	IR

IR	**Integrated isolator + reflected power meter**		
x	Cooling	**1**	1 Air /air
		3	3 Air / water
xxx	Control	**FST**	Digital front panel, local remote control, analogue and RS232
		XST	Without digital front panel, analogue and RS232 remote control (protocol SAIREM)
		XPR	Without digital front panel, PROFIBUS® remote control
		XMS	Without digital front panel, ModBus on RS232 control, allows to drive a single slave
		XMM	Without digital front panel, ModBus on RS485 or RS422 control, allows to drive multiple slaves with one RS485 or RS422 port
		XCA	Without Digital front panel, CanOpen remote control
56xxxx	50/60 Hz	**M230**	Single phase 230 V
		T400	3 phase + earth, 400 V
		T208	3 phase + earth, 208 V
xx	Pulsed or not?	**SM**	Continuous mode
		IP	Internal pulse mode (integrated pulse generator)
xxK	Max power level	**20**	2000 W
		30	3000 W
		60	6000 W
GMP		**150**	15 000 W
	Microwave Power Generator		

SAIREM's **Automatic Restart Function** (ARF) allowing to detect magnetron arcing and its immediate automatic restart - operator adjustable from 5 to 50 ms.

KEY POINTS & BENEFITS

- From 0 to 30 kW
- Output power adjustable with 10 W step
- Power stability higher than 1 %
- Rise and fall times about 100 µs with pulsed models
- Very low ripple (0.2 % RMS) and high power efficiency
- PROFIBUS®, CanOpen, Modbus, analogue...
- Microwave head, isolator and reflected power measurement integrated in the most compact design of the market
- Quick-release connectors for high-voltage and water cooling

APPLICATIONS

- Electrodeless plasma processing, i.e. minimum corrosion & contamination
- Controlled atmosphere
- Ideal for PVD, PECVD, diamond deposition hybrid processes, etching, gas treatment, nanoparticles synthesis...

CONTACT US

commercial@sairem.com
www.sairem.com

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SAIREM, 12 porte du Grand Lyon, 01700 Neyron, France, www.sairem.com / Tel : +33 (0)4 72 01 81 60 / Fax : +33 (0)4 72 01 81 79

SOLID STATE 2.45 GHz MICROWAVE GENERATORS 200 W & 450 W

200 W 2.45 GHz
Solid State Microwave Generator

450 W 2.45 GHz
Solid State Microwave Generator

DESCRIPTION

SAIREM's solid state microwave generators produce up to 200 W or 450 W maximum power at 2450 MHz.

They provide continuous wave (CW) operation at frequencies ranging between 2400 MHz and 2500 MHz.

These generators are designed for scientific and industrial applications, to be used with one or multiple MW applicators, to assure high reliability and small footprint. The protection against high reflected power & measurement of reflected power are performed via a built-in isolator.

KEY POINTS AND BENEFITS

- From 1 W to 200 W or 450 W adjustable in 1 W step
- Adjustable frequency 2450 MHz ± 50 MHz
- Semiconductor technology (longer lifetime than magnetron & no high voltage)
- Very good frequency spectrum even at low power
- Built-in isolator with automatic power reduction or switch off
- Compact size & lighter weight: 1 single case, microwave energy transmitted via coaxial cable
- True RMS detector with linear measurement of reflected and forward power
- Very low ripple (< 0.2 % RMS) and high power efficiency
- Sairem auto-tune algorithm to control the frequency automatically to minimize the reflected power
- For industrial applications requiring multiple applicators, a water cooled solid state module is available; its simple operation is ensured via analogue and PROFIBUS® or CANOPEN® remote control

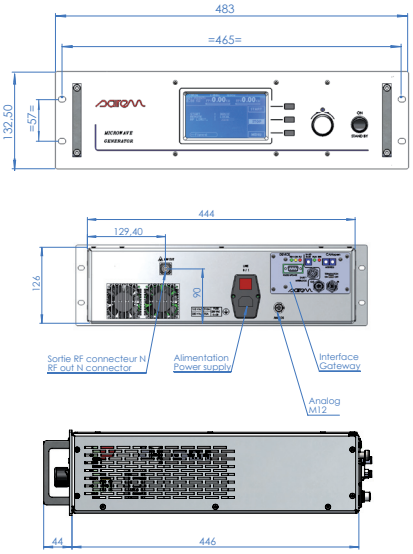
WHY CHOOSE SAIREM'S SOLID STATE MICROWAVE GENERATOR ?

- Proven industrial experience for Sairem solid state generators. Hundreds of Sairem solid state generators and modules operating worldwide
- Sairem auto-tune alogorithm reflected power reduction by automatic frequency adjustment
- Compatibility with existing Sairem plasma sources : Aura-Wave, Hi-Wave and S-Wave
- Available as a compact rack version of 4 modules with a control unit (touch screen and a user-friendly interface)
- Wide range of solid state generator available :
  - 600 W at 915 MHz
  - 300 W to 8 kW at 13.56 and 27.12 MHz

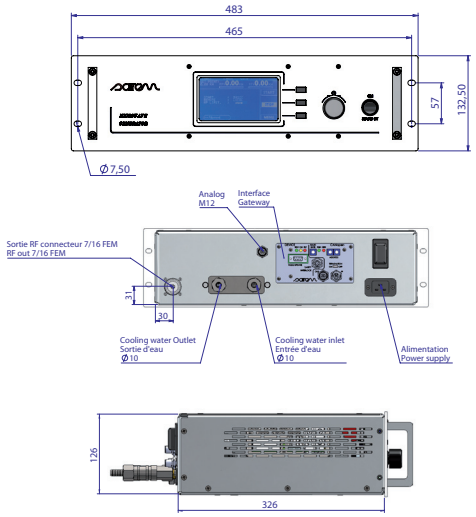
200 W 2.45 GHz
Solid State
Microwave Module

SOLID STATE 2.45 GHz MICROWAVE GENERATORS 200 W & 450 W

GMS 200 W



GMS 450 W



	GMS 200 W	GMS 450 W
Microwave output	Power supply with N connector output	Power supply with 7/16 connector output
Output power	0 to 200 W (adjustable with 1 W step) ± 2 %	0 to 450 W (adjustable with 1 W step) ± 2 %
Reflected power	Protected up to 300 W Automatic limitation of forward power to keep reflected power at 100 W maximum	Protected up to 300 W Automatic limitation of forward power to keep reflected power at 200 W maximum
Consumption	700 VA max. at 200 W	1200 VA max. at 450 W
Weight	11.8 kg	12 kg
Dimensions	Height x width x depth 126 x 444 x 446	Height x width x depth 126 x 444 x 326
Cooling	Air cooled	Water cooled; flow and temperature sensors included
Frequency	2.45 GHz / Frequency resolution: 2400 - 2500 MHz adjustable with 100 kHz step	
Matching	SAIREM auto-tuning algorithm: reflected power reduction by automatic frequency adjustment	
Forward and reflected power measurement	Coupler with true RMS detector – linear measurement	
Ripple	< 0.2 % RMS	
Protection functions	VSWR (built-in isolator with automatic power reduction), excess temperature (overheating interlock), water flow (for GMS 450 W)	
Control	- Rack version Local : front panel Remote: Modbus RTU RS232 (standard version) or RS485 or Ethernet, ProfiBus, CanOpen Analogue input set point for forward power control (0-10 V), analogue output for forward and reflected power (0-10 V) - Module version: ProfiBus® or CanOpen®	
Mains	1 phase, 110 V to 240 V, 50/60 Hz	
Security	A safety connector ensures safety standard for machines and personnel	
Operation requirements	Operating ambient temperature : 5 to 35 °C (41 °F to 95 °F). Water temperature for cooling : 17 °C to 22 °C (63 °F to 72 °F). Ambient humidity level < 50 %	

CONTACT US

commercial@sairem.com
www.sairem.com

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SAIREM, 12 porte du Grand Lyon, 01700 Neyron, France / Tel : +33 (0)4 72 01 81 60

SOLID STATE 915 MHz MICROWAVE GENERATOR 600 W

600 W 915 MHz
Solid State Microwave Generator

DESCRIPTION

SAIREM's solid state generator at 915 MHz provides continuous wave (CW) and pulse mode operation with output power adjustable from 0 to 600 W at frequencies ranging from 902 MHz to 928 MHz.

This generator is designed for scientific and industrial applications, to be used with one or multiple MW applicators, to assure high reliability and small footprint. The protection against high reflected power & measurement of reflected power is performed via a built-in isolator.

KEY POINTS AND BENEFITS

- From 1 W to 600 W adjustable in 1 W step
- Adjustable frequency 915 MHz ± 13 MHz
- Semiconductor technology (longer lifetime than magnetron & no high voltage)
- Very good frequency spectrum even at low power
- Built-in isolator with automatic power reduction or switch off
- Compact size & lighter weight: 1 single case, microwave energy transmitted via coaxial cable
- True RMS detector with linear measurement of reflected and forward power
- Very low ripple (< 0.2 % RMS) and high power efficiency
- Sairem auto-tune algorithm to control the frequency automatically to minimize the reflected power
- For industrial applications requiring multiple applicators, a water cooled solid state module is available; its simple operation is ensured via analogue and PROFIBUS® or CANOPEN® remote control

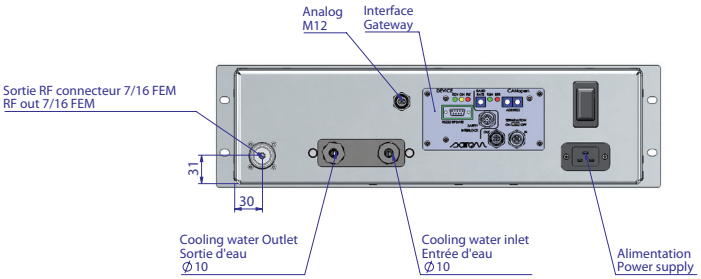
WHY CHOOSE SAIREM'S 915 MHZ SOLID STATE MICROWAVE GENERATOR ?

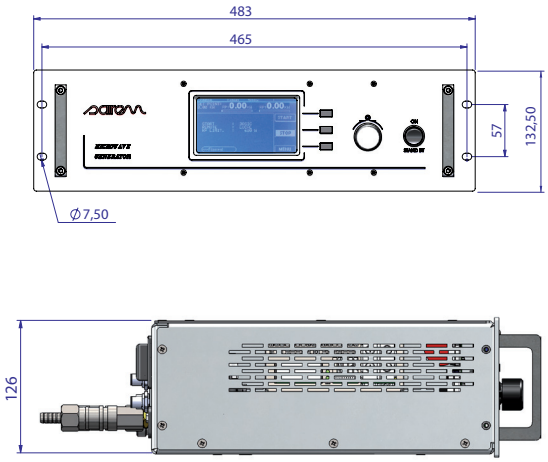
- Proven industrial experience for Sairem solid state generators. Hundreds of Sairem 2.45 GHz solid state generators and modules operating worldwide
- Sairem auto-tune algorithm reflected power reduction by automatic frequency adjustment
- Compatibility with existing Sairem plasma sources: Aura-Wave 915 MHz (soon Hi-wave and S-wave)
- Available as a compact rack version of 4 modules with a control unit touch screen and a user-friendly interface control unit
- Wide range of solid state generator available:
  - 200 W and 450 W at 2.45 GHz
  - 300 W to 4 kW at 27.12 and 13.56 MHz

600 W 915 GHz
Rear of the Solid State Microwave Generator

SOLID STATE 915 MHz MICROWAVE GENERATORS 600 W

GLS 600 W





	GLS 600 W
Frequency	915 MHz / Frequency resolution : 902 to 928 MHz adjustable with 100 kHz step
Output power	0 to 600 W (adjustable with 1 W step) ± 2 %
Reflected power	Protected up to 300 W Automatic limitation of forward power to keep reflected power at 300 W maximum
Consumption	1500 VA max. at 600 W
Weight	13 kg
Dimensions	Height x width x depth 126 x 446 x 326
Cooling	Water cooled; flow and temperature sensors included
Matching	SAIREM auto-tuning algorithm: reflected power reduction by automatic frequency adjustment
Pulse mode	Rise time < 1 ms, fall time < 1.5 ms Duty cycle: 10 % to 90 %
FRPM	Forward and reflected power measurement Coupler with true RMS detector – linear measurement
Ripple	< 0.2 % RMS
Protection functions	VSWR (built-in isolator with automatic power reduction), excess temperature (overheating interlock), water flow
Control	- Rack version Local : front panel Remote: Modbus RTU RS232 (standard version) or RS485 or Ethernet, ProfiBus, CanOpen Analogue input set point for forward power control, analogue output for forward and reflected power - Module version: ProfiBus® or CanOpen®
Mains	1 phase, 110 V to 240 V, 50/60 Hz
Security	A safety connector ensures safety standard for machines and personnel
Operation requirements	Operating temperature: 5 to 35 °C (41 °F to 95 °F). Water temperature for cooling: 17 °C to 22 °C (63 °F to 72 °F). Ambient humidity level < 50 %

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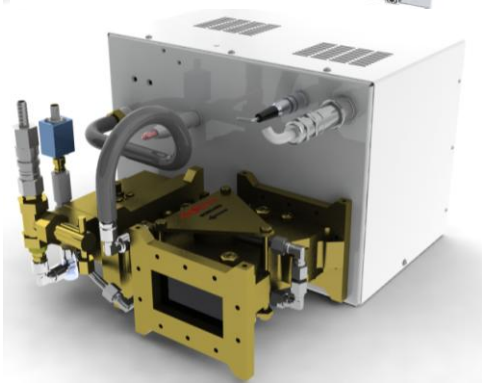
6000 W, 2450 MHz Microwave Generator
GMP 60K SM 56T400 FST 3 IR

Power supply
It is based upon the latest switch mode power supply technology, **offering size reduction** (smallest 6 kW available on the market, i.e. 19'' rack, 3U power supply), good power stability and significantly reduced electrical losses. The efficiency of the switch mode power supply is higher than 93 %. A real interlock is available for safety.

Microwave head - compact size
This new head includes a water cooled magnetron and the filament transformer. An isolator with its reflected power crystal detector is connected to the microwave head. Quick release connectors for water cooling and high voltage are used on both the power supply and the microwave head. A water flow meter is connected at the exit of the cooling circuit of the isolator; this water sensor acts as an interlock which will completely shut down the microwave generator if not enough water flow is sensed.



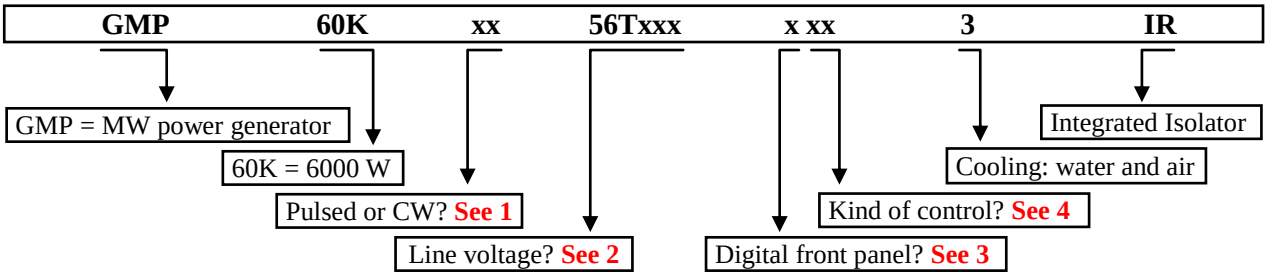
Reference	**GMP 60K -- 56T--- --- 3 IR**
Presentation	Switch mode Power supply (η > 93 %) with separate microwave head Connecting cable: 4 m standard length. Other lengths on request
Frequency	2450 MHz ± 25 MHz
Output microwave power	6 kW adjustable from 10 % to 100 % with 10 W step
Power stability	1 % from 10 % to 100 %
Ripple	< 1 % RMS from 10 % to 100 %
Waveguide output	WR340
Maximum SWR	Infinite at any phase with isolator
MW operating mode (*)	Continuous or pulsed
Power rise & fall times	< 50 µs / 50 µs with **IP** pulsed model
Versions available (*)	With or without digital front panel Digital front panel is used for local remote control
Mains (*)	400 V ± 10 %, 3-phase + earth with integrated filter 208 V ± 10 %, 3-phase + earth with integrated filter
Display of forward & reflected powers	On blue LCD screen (version with digital front panel) On serial link and / or on analogue interface
Start mode (*)	Standard On/Off, Plasma starting, ramp (with digital front panel)
Remote control (*)	Analogue and RS232, Modbus on RS232 or RS485, Profibus®, CanOpen
Consumption	9700 VA (power factor > 0.9)
Weight	Power supply 23 kg, microwave head 23 kg (including isolator)
Cooling	Power supply, microwave head & isolator: air and water (min. water flow 6 L/min with 2.5 bar (between inlet & outlet)
Operating temperature	Ambient max. 40 ^{0}C, cooling water 18 – 23 ^{0}C
Connectors	Quick connectors for high voltage and water cooling
Safety interlock	Safety relay and free contact to be shunted
ARF	Automatic Restart Function allowing to detect magnetron arcing and its immediate automatic restart
Complies with norms	Safety: EN 61010-10, EMC: EN 61000-6-4 and EN 61000-6-2

12 porte du Grand Lyon, 01702 Neyron Cedex, France, www.sairem.com
Tel : +33 (0)4 72 01 81 60, Fax : +33 (0)4 72 01 81 79, E-mail : commercial@sairem.com

(*) depending on the version

How to choose your 6 kW microwave generator?

References explanation



To help you choose the right 6 kW microwave generator for your application, please use the following questionnaire:

1. Pulsed or continuous wave? GMP 60K SM 56T400 XST 3 IR

- **SM** version is recommended for continuous wave operation
- With the **IP** version (internal pulse), you can choose the parameter of your pulse directly from the digital front panel or by software (frequency and duty cycle or ON time and OFF time)

2. Line voltage? GMP 60K SM 56T400 XST 3 IR

There exist two possibilities:

- 50/60 Hz, 3-phase 208 V + earth, i.e. **56T208**
- 50/60 Hz, 3-phase 400 V + earth, i.e. **56T400**

3. With or without digital front panel? GMP 60K SM 56T400 XST 3 IR

- With digital front panel **F**: for local and visual control of the generator
- Without digital front panel **X**: control of the generator only via remote control

4. How to drive the generator? GMP 60K SM 56T400 XST 3 IR

- **ST**: Standard analogue and RS232 remote control (protocol SAIREM). Recommended if you have only one generator to drive. A Human Machine Interface could be developed on demand
- **PR**: PROFIBUS® industrial bus. Allows to drive multiple slaves
- **CA**: CanOpen industrial bus. Allows to drive multiple slaves
- **MS**: ModBus on RS232 control. Allows to drive a single slave, the generator is provided with a Labview driver which could be integrated in other Labview process
- **MM**: ModBus on RS485 or RS422 control. Allows to drive multiple slaves with one RS485 or RS422 port, the generator is provided with a Labview driver which could be integrated in other Labview process

12 porte du Grand Lyon, 01702 Neyron Cedex, France - www.sairem.com
Tel : +33 (0)4 72 01 81 60, Fax : +33 (0)4 72 01 81 79, E-mail : commercial@sairem.com

CONTROL AND OPERATION OF MICROWAVE GENERATORS WITH DIGITAL DISPLAY

GMP 60K SM 56T400 FST 3 IR

The generator with digital front panel is wholly operated in local mode from the control panel located at the front of the power supply rack.
The front panel consists of a large white over blue graphical LCD screen 240 x 128 pixels, 3 push buttons and a knob for menu navigation and power control.

All operating parameters and control status, as well as any possible fault, forward power and reflected power are displayed on the screen. The forward power set-point is pre-displayed before starting.

Main operating functions:

- Start mode:
  - Standard mode ON/OFF
  - Overshoot mode
  - Ramp mode (adjustable from 0 to 30 s)

- Control mode
  - Local
  - Remote control

- Control of reflected power
  - Adjustable from 0 to 100 % of forward power
  - Disjunction mode or limit mode of forward power (sound signal)

- Various
  - Fault list
  - Filament hour counter

- Configuration
  - Preset and load configuration
  - Language (English or French)

12 porte du Grand Lyon, 01702 Neyron Cedex, France - www.sairem.com
Tel : +33 (0)4 72 01 81 60, Fax : +33 (0)4 72 01 81 79, E-mail : commercial@sairem.com

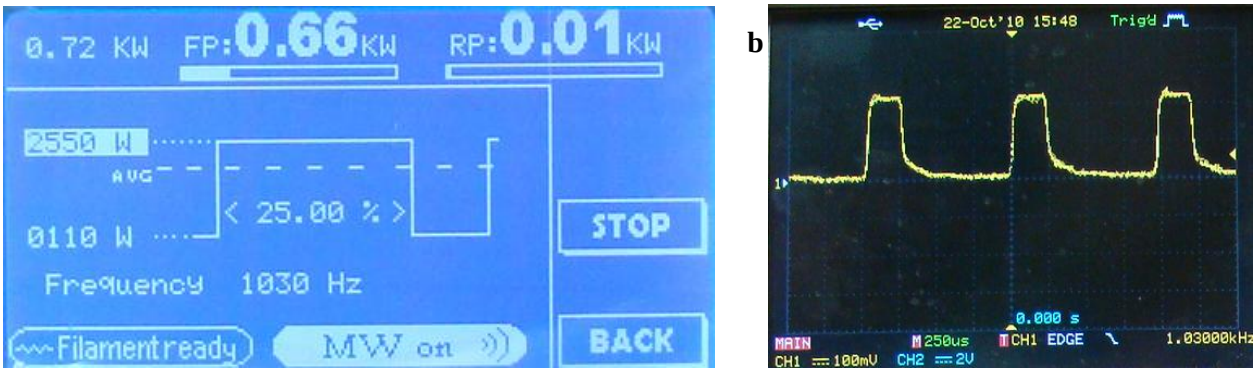
CONTROL AND OPERATION FOR THE INTERNAL PULSE VERSION

GMP 60K IP 56T400 FST 3 IR

The internal pulse mode integrated with the **IP** generator can be set up from the digital control panel of the power supply unit; a remote control is available at the rear of the power supply unit via PROFIBUS®, CanOpen or Modbus (RS2332 or RS485).

All operating pulse parameters are displayed on the screen as follows:
- Pulse maximum, minimum and average power level
- Pulse duty cycle and frequency
- Time ON/OFF

a **b**



a) Set up of the pulse on the digital display, b) corresponding microwave output measurement

Main pulse parameters:

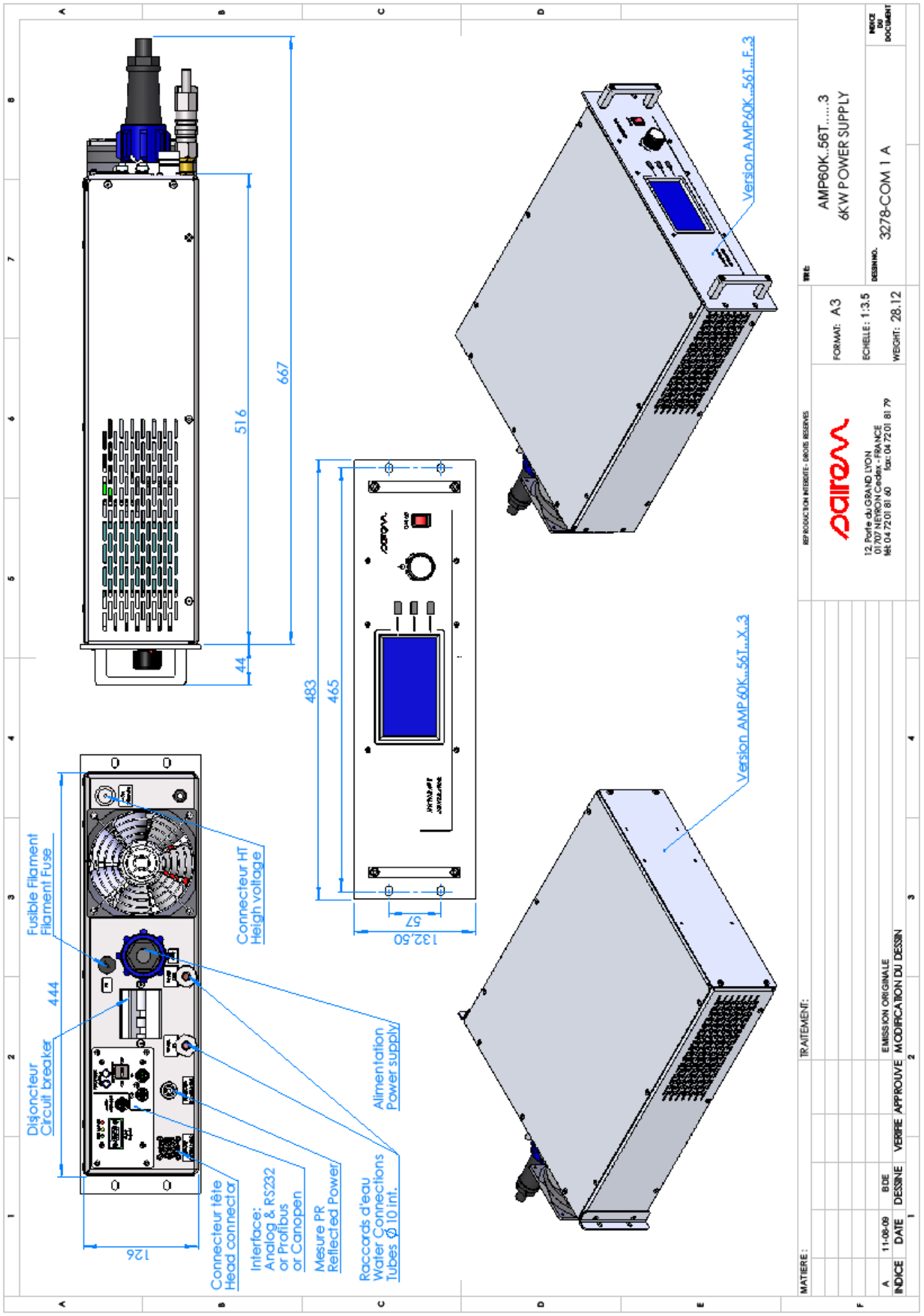
- Frequency: from 0.25 to 2500 Hz

- Duty cycle: from 1 to 99 %, 10 % min at 1000 Hz, 20 % min at 2000 Hz

- Rise and fall time: < 50 µs

- Minimum pulse duration: 100 µs

12 porte du Grand Lyon, 01702 Neyron Cedex, France - www.sairem.com
Tel : +33 (0)4 72 01 81 60, Fax : +33 (0)4 72 01 81 79, E-mail : commercial@sairem.com



12 porte du Grand Lyon, 01702 Neyron Cedex, France - www.sairem.com
Tel : +33 (0)4 72 01 81 60, Fax : +33 (0)4 72 01 81 79, E-mail : commercial@sairem.com

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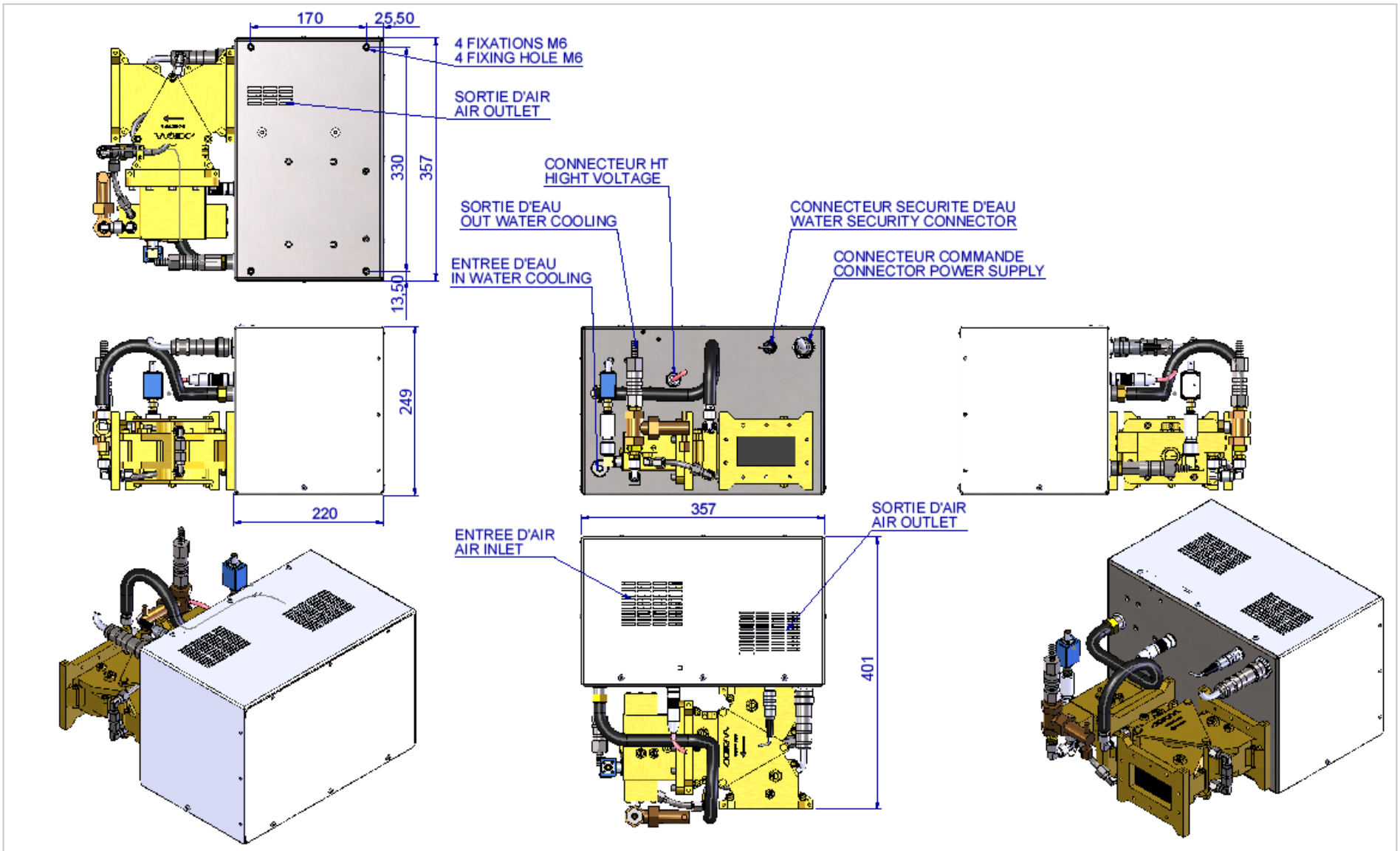


INDICE	DATE	DESSINE	VERIFIE	APPROUVE	MODIFICATION DU DESSIN
A	12/01/11	ML			EMISSION ORIGINALE

sairem
12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com

FORMAT: A3
ECHELLE : 1:5
WEIGHT:

TITLE:
6KW 2450MHz POWER HEAD
ISOLATEUR B
TETE MO 6KW

DESSIN NO.
3351-ENS

GMP100 MICROWAVE GENERATOR
10 kW AT 2450 MHz

SAIREM's latest generation (G4) of microwave generators has been specially designed **for customers' industrial applications and plasma generation.** The 100 % digital architecture makes it a **modern and highly reliable product**, with smart power control.

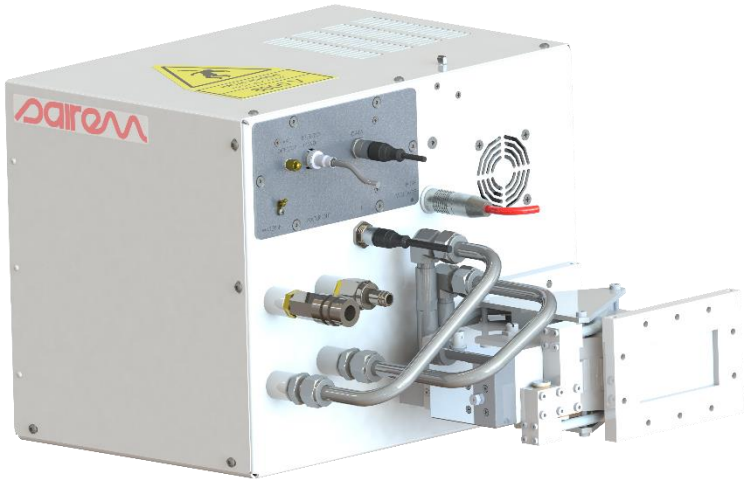
Multiple features, like the **Automatic Restart Function** (ARF), and **Preventive Alarm Management** (PAM, alarms without stopping the production) are implemented to allow you **to go to the end of your process**, even in case of micro power-cuts.

Finally, SAIREM's comprehensive customer service help you to **maximize your production yield,** through support and advices.

APPLICATIONS

LABORATORY APPLICATIONS

- Microwave-assisted liquid or solid chemistry
- Biochemistry
- Drying
- Sintering
- Melting



PLASMA APPLICATIONS

- CVD and CVD for diamonds
- Plasma generation with surface wave plasma source (Downstream, Surfaguide, Dual-stream …)
- Nitriding
- Thin film deposition

INDUSTRIAL APPLICATIONS

- Microwave-assisted liquid or solid chemistry
- Drying
- Melting

82 rue Elisée Reclus
69150 Décines-Charpieu
France
www.sairem.com
welcome@sairem.com
Tel: +33 472 018 160

GMP100 MICROWAVE GENERATOR
10 kW AT 2450 MHz

KEY BENEFITS

COMPACT 2 MODULES DESIGN

- 10 kW rackable Power Supply (19" 4U)
- 10 kW 2450MHz Microwave Head

BEST IN CLASS RELIABILITY

- **Automatic Restart Function (ARF)** in less than 5 ms, to avoid production stop or loss
- **Environment monitoring**: 35 parameters.
- Custom designed SAIREM magnetron, with high reliability and spectrum stability
- Expected Magnetron **lifespan above 15000 hours**, depending on operating conditions
- **Arc detection** included. One arc input is also available for customer's applicator/process.
- **Preventive Alarm Management (PAM)** that allows the continuation of the production
- **100 % digital design** offers better protection from the electrical network interferences and distortions
- Software compatible with previous generation (no need to change control software)
- **Comprehensive customer service**

CONTROLS

- **7" color TFT touch screen** (option) for easy and efficient control and configuration. Full-screen power display function available to read power easily even far away from the generator.
- Full digital design to allow smart power control.

COMMUNICATION

- **Ethernet connection** for online diagnostic. USB port available to export alarm messages for easy diagnostic.
- Many fieldbus interfaces available
- **Can be ordered without digital display** to save cost. Remote control only, by fieldbus
- Full upgradable USB inlet

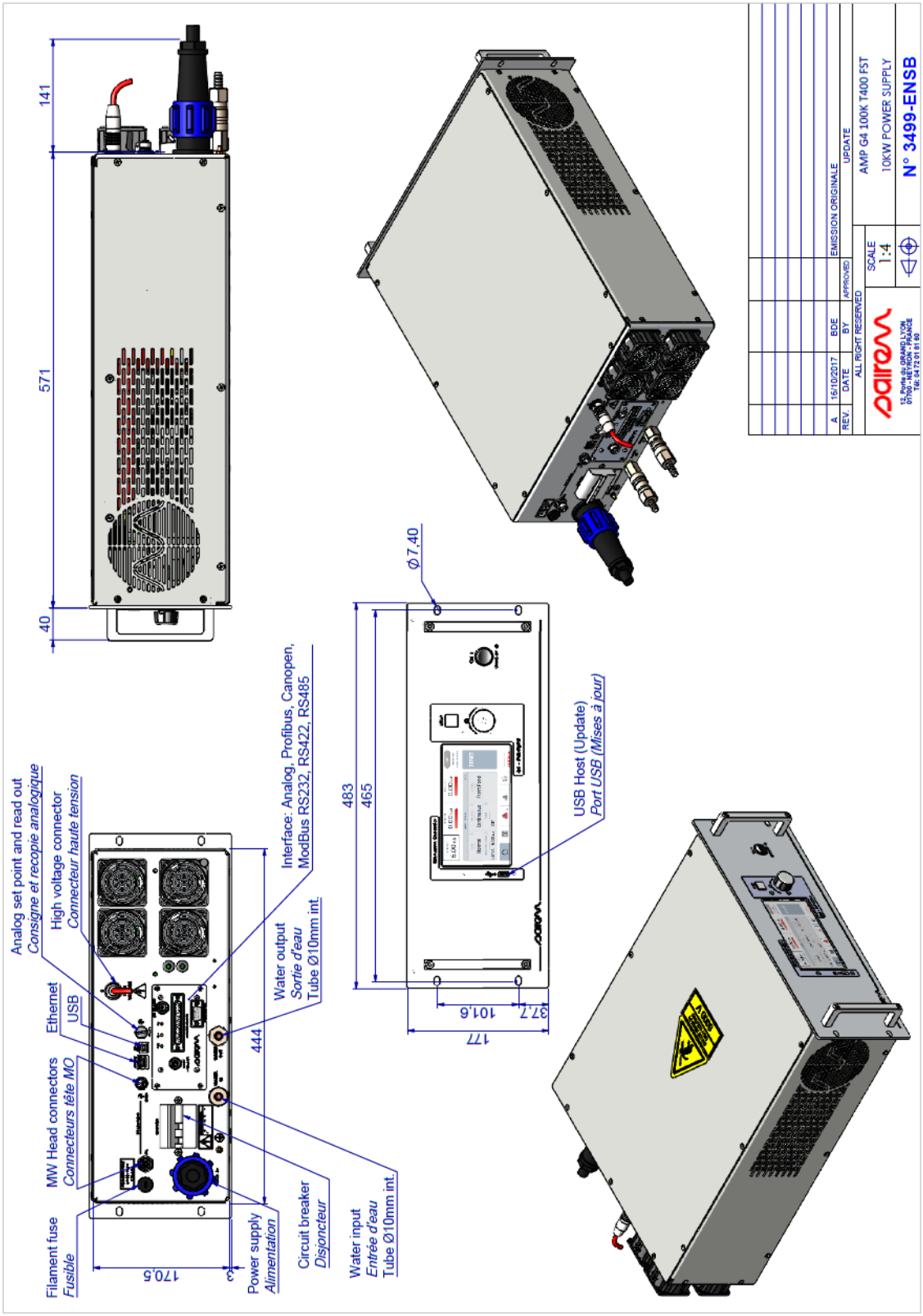
GMP100 MICROWAVE GENERATOR
10 kW AT 2450 MHz

KEY SPECIFICATIONS

Reference	**GMP G4 100K AA TXXX YZZ H**
Presentation	Switch mode Power supply (η > 90 %) with separate microwave head Connecting cable: 5 m standard length; 2,5 m / 10 m / 15 m / 20 m optional - Other lengths available upon request.
Frequency	2450 MHz ± 25 MHz
Output microwave power	10 kW adjustable from 10 % to 100 %, with 10 W steps
Power stability	1 % from 10 % to 100 %
Ripple	< 2 % RMS (Root Mean Square) from 10 % to 100 % of nominal power
Parameters	Measure of 35 parameters: output power, reflected power, water temperature, water flow, humidity, inside and ambient temperature, high voltage monitoring …
Waveguide output	WR340
Maximum reflected power	100% for one minute maximum
MW operating mode ([1])	Continuous ([SM]) or pulsed ([IP])
Mains ([2])	• 400 V ± 10 % ([400]), 3-phase + earth with integrated filter • Or 480 V ± 10 % ([480]), 3-phase + earth with integrated filter
Display ([3])	With 7" TFT color touch screen ([F]) or without ([X]) digital front panel (local control)
Start mode	Standard On/Off, Plasma starting, ramp (with digital front panel)
Remote control ([4])	"EtherNet/Industrial Protocol (IP)" always available + to be chosen: Analogue ([ST]) OR Modbus on RS232 ([MS]) OR Modbus RS485 ([MM]) OR Profibus® ([PR]) OR CanOpen ([CA]).
Safety interlock	Safety relay and free contact to be shunted
Automatic Restart Function (ARF)	Detect all faults (including magnetron arcing) and automatically attempt to restart in less than 5 ms up to 3 times
Cooling system	Air and water (min. water flow 7 L/min with 2.5 bar between inlet & outlet, warning between 7 and 8 L/min) Cooling water between 18° to 23°C (other ranges available on demand)
Operating environment	Max. ambiant temperature : 40°C. Maximum humidity : 60 % non-condensing
Safety Standards	• Safety: EN 61010-10 • EMC: EN 61000-6-4 and EN 61000-6-2
Connectors	Quick connectors for high voltage, mains line and water cooling
Consumption	16000 VA (power factor > 0.9)
Overall Dimensions (LxWxH)	• Power supply: 752 x 483 x 177 mm • Microwave generator head: 436 x 357 x 279 mm
Weight	• Power supply: 25 kg • Microwave generator head: 22 kg (including isolator)

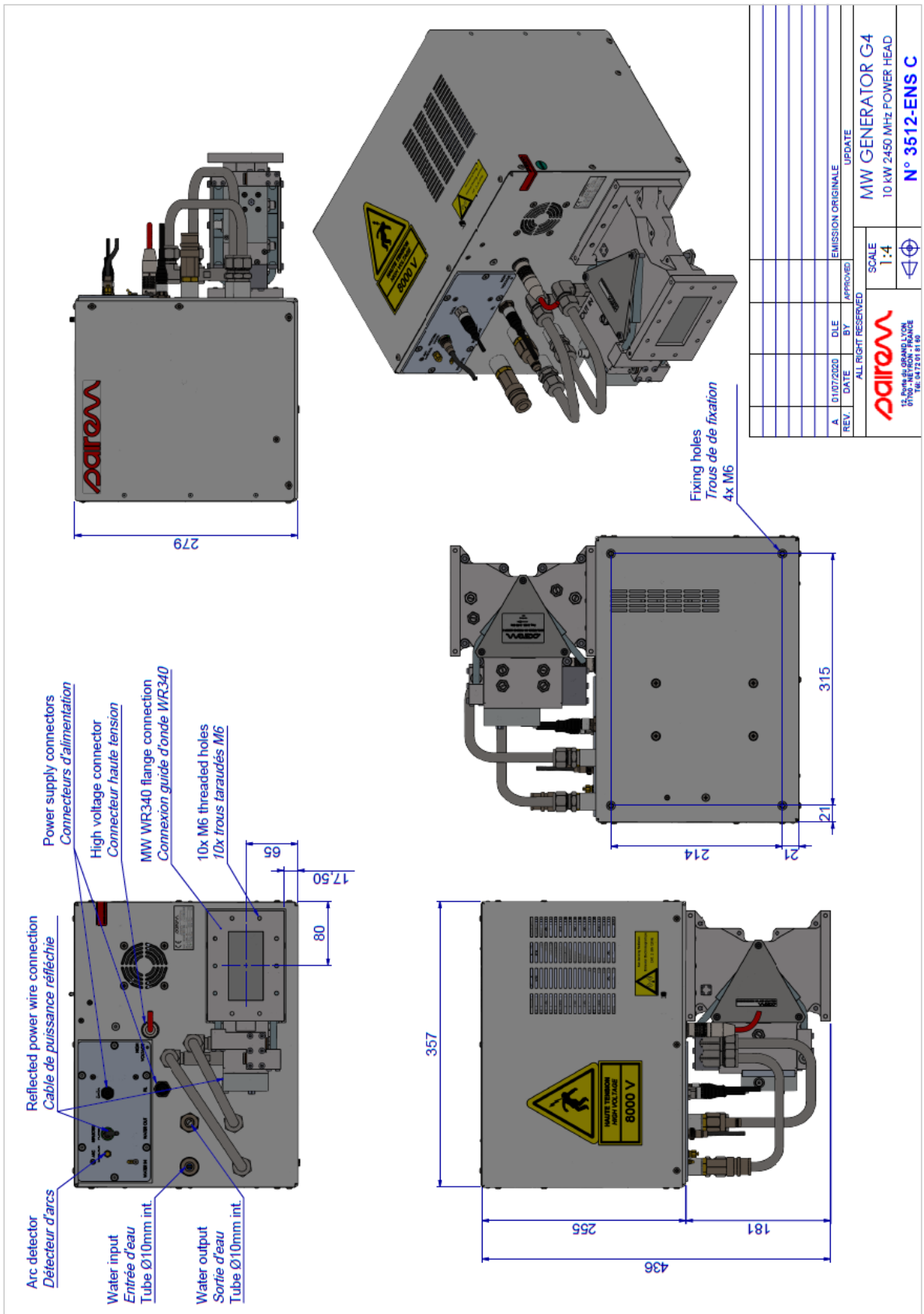
MAIN DIMENSIONS

POWER SUPPLY MODULE



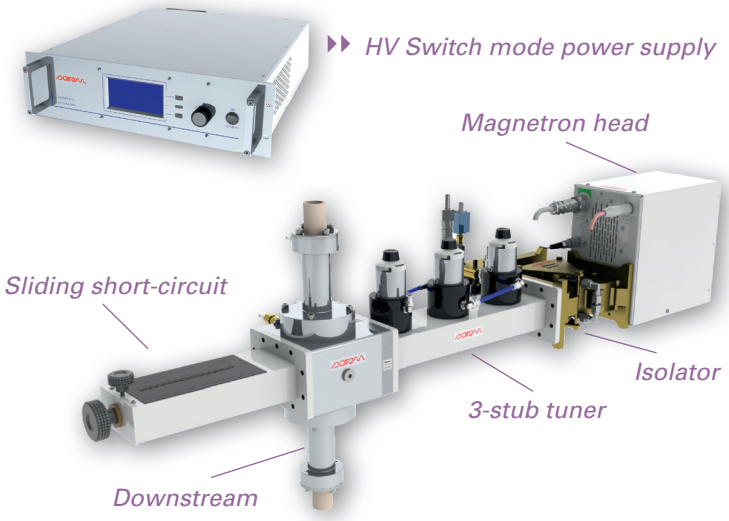
GMP100 MICROWAVE GENERATOR
10 kW AT 2450 MHz

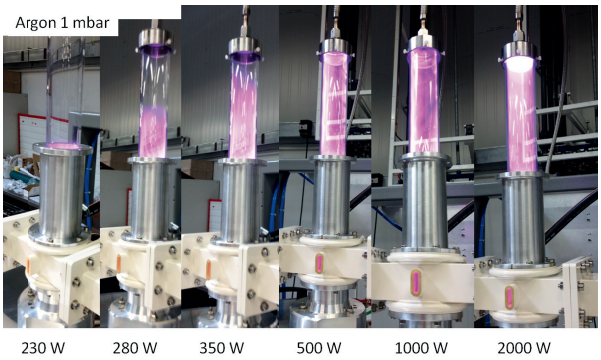
MICROWAVE GENERATOR MODULE

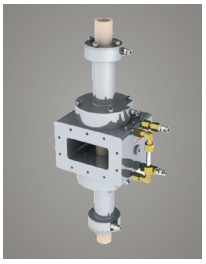


2.45 GHz SURFACE WAVE PLASMA SOURCES

STANDARD DOWNSTREAM SET-UP

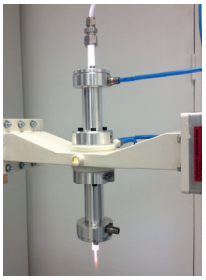






DOWNSTREAM

Pressure range	10^{-2} mbar to atmospheric pressure
Gas type	Ar, N_2, O2, H_2, CH_4, He, air, ...
Maximum power	6 kW
Application type	Creation of radicals, reactive species, surface activation, PECVD, gas abatement, gasification, sterilization, nanopowder synthesis



SURFAGUIDE

Pressure range	10^{-2} mbar to atmospheric pressure
Gas type	Ar, N_2, O_2, He, air, ...
Maximum power	6 kW
Application type	Creation of radicals, reactive species, surface activation, PECVD, gas abatement, gasification, sterilization, atmospheric high temperature chemistry

S-WAVE

Pressure range	10^{-2} mbar to atmospheric pressure
Gas type	Argon or argon based gas mixture at atmospheric pressure. All gases at reduced pressure
Maximum power	300 W
Application type	Creation of radicals, reactive species, surface activation, elementary analysis

KEY POINTS & BENEFITS

- Over dense plasmas, high ions and active species densities
- High temperature plasmas at atmospheric pressure
- Extremely wide operating pressure range: large application spectrum
- Electrodeless: independence of targets and substrate bias voltage

CONTACT US

commercial@sairem.com
www.sairem.com

Your partner in Microwave & Radio Frequency professional solutions

SAIREM, 12 porte du Grand Lyon, 01700 Neyron, France / Tel : +33 (0)4 72 01 81 60 / Fax : +33 (0)4 72 01 81 79

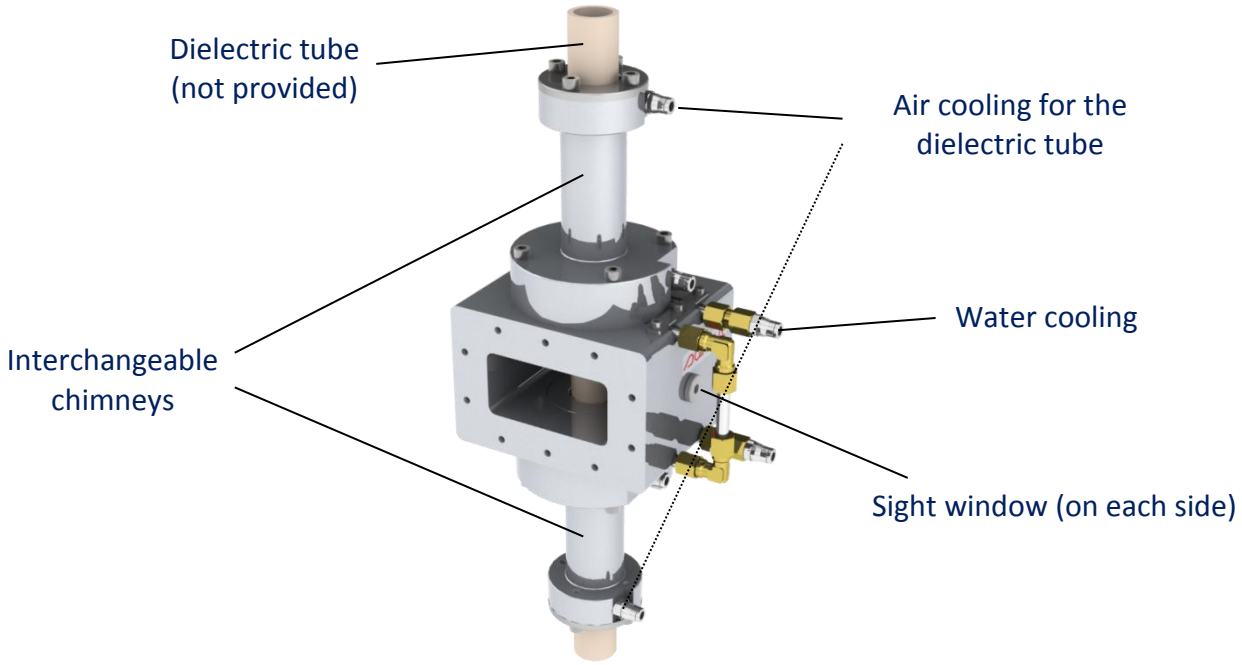
DOWNSTREAM PLASMA SOURCE WR340

DOWNSTREAM WR340 3 XX

This surface wave type of plasma source generates plasma in a dielectric material tube placed in a standard WR340 waveguide. This plasma source enables the ignition and sustaining of long plasma columns depending on the pressure, the microwave power and the gas nature.
The Downstream plasma source is ideal for working at pressures between 10^{-1} mbar and a few tens of mbar with dielectric tubes diameters between 30 and 50 mm; it can equally work at atmospheric pressure.
The Downstream plasma source WR340 is designed to be used in R&D laboratories and industry for a very large range of applications. Typical applications of such source are creation of radicals, surface activation, PECVD (dielectric materials, diamond...), gas abatement, gasification, sterilization, etching...

The Downstream plasma source could be used with an alumina tube but other low loss, high temperature resistant dielectric materials such as quartz, Pyrex™ or boron nitride could be used. Inlet and outlet chimneys were designed to sustain and centre the dielectric tube. Moreover, in order to extend the operating conditions in the atmospheric pressure range and/or in the high power range, the dielectric tube can be air cooled and the downstream source can be water cooled.

Downstream plasma source WR340



Technical specifications

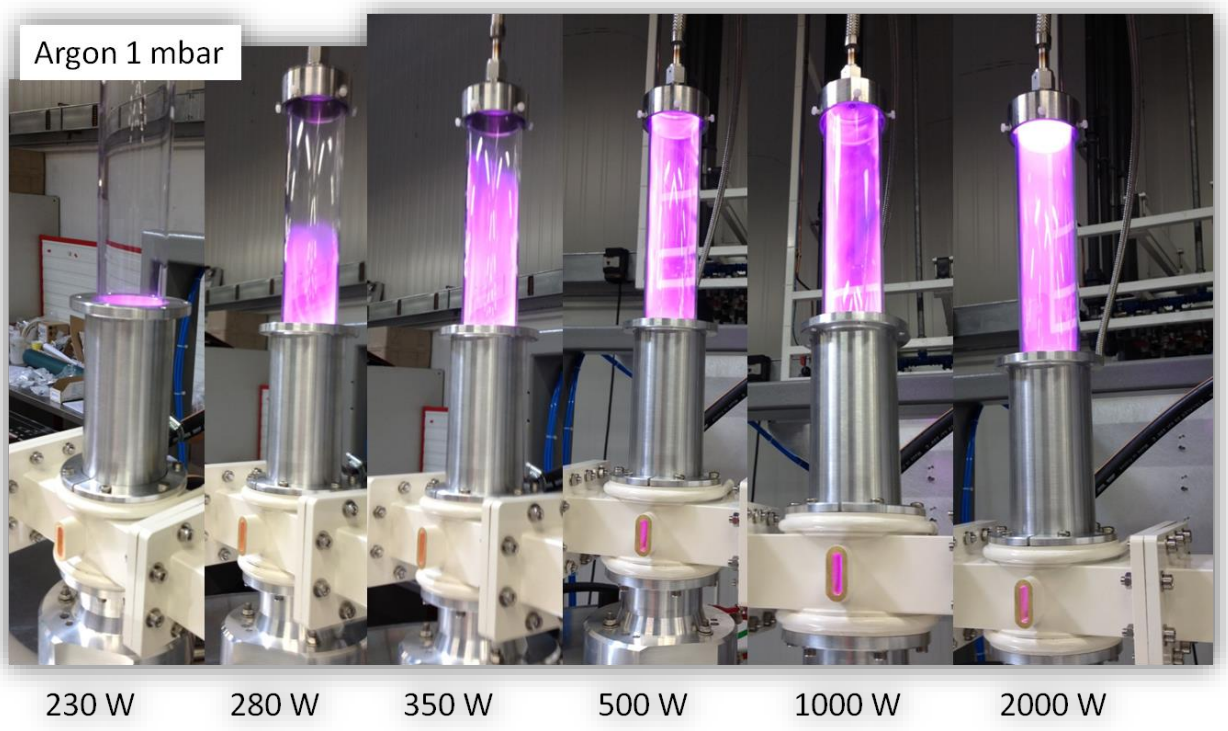
REF	DOWNSTREAM WR340 3 XX*
Frequency	2450 MHz ± 25 MHz
Microwave power	Max. 6 kW
Working pressure range	A few 10^{-2} mbar to atmospheric pressure
Connections	Standard WR340 flange (UG 553 A/U, RG 112/U)
Discharge tube external diameter	30 mm, 40 mm or 50. MUST be specified when ordering. **Tube not provided**
Cooling	Water, quick connectors for OD 8 mm tubing Air, quick connectors for OD 6 mm tubing
Weight	cca 2.7 kg

*XX = external diameter of the discharge tube

OBSERVATIONS

1. Inlet and outlet chimneys are interchangeable and matched to the external diameter of the dielectric tube; additional chimneys for dielectric tube OD 30, 40 and 50 can be ordered;
2. The use of a microwave adapted window (alumina, quartz) between the microwave generator and the Downstream source is strongly recommended - to prevent accidental arcing travelling back to the magnetron and equally to act as a barrier/seal to protect the magnetron against any debris/corrosive agents that could escape from the plasma source and cause irreversible damage to the magnetron and isolator.

Argon plasma column in downstream source at 1 mbar vs. microwave power

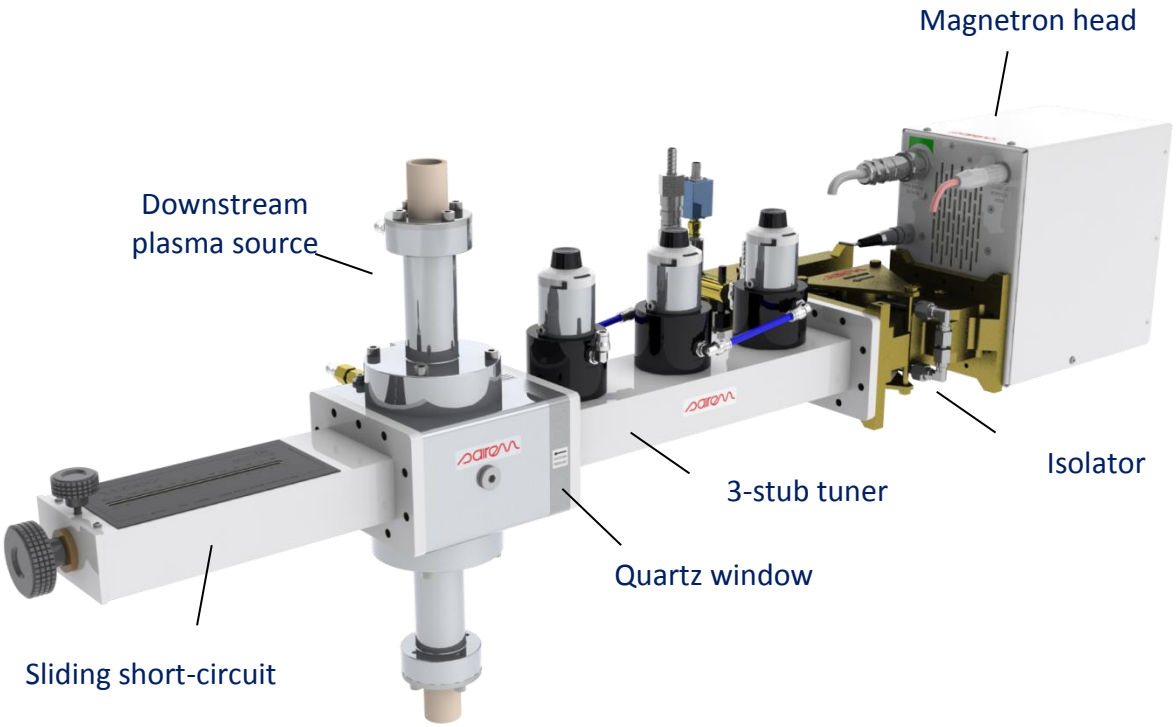


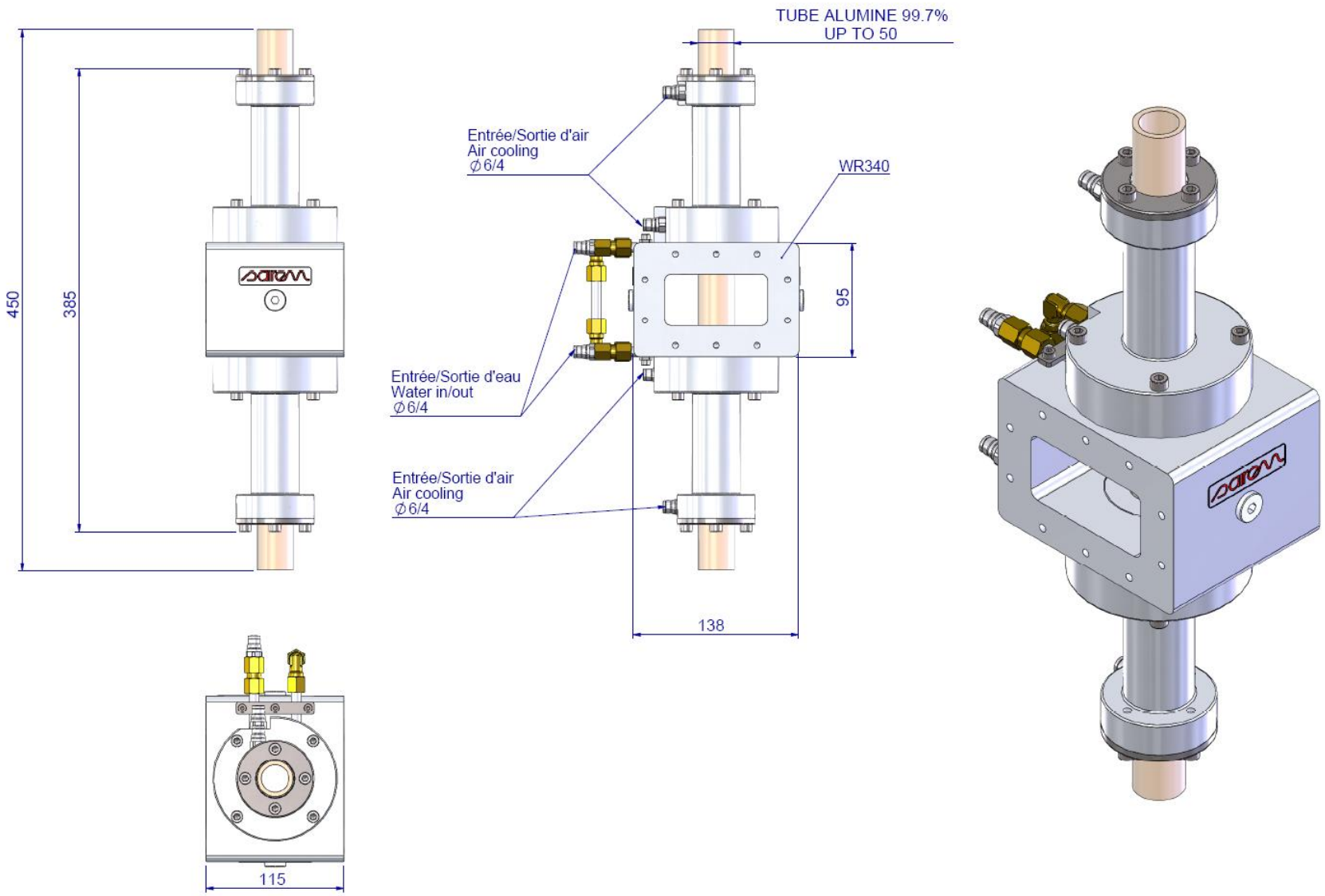
COMMON ASSEMBLY

The functionality of this plasma source is possible if the source is connected to a 2.45 GHz microwave generator and means of impedance tuning, e.g. manual short circuit, 3-stub tuner, iris etc.

Standard Downstream set-up

Switch mode power supply





INDICE	DATE	DESSINE	VERIFIE	APPROUVE	MODIFICATION DU DESSIN
A	02-08-13	BDE			EMISSION ORIGINALE

12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com

FORMAT: A3

ECHELLE : 1:3

WEIGHT: 2.70

TITRE:
DOWNSTREAM ALU
WR340 2450 MHz

DESSIN NO.
3007-ENS D

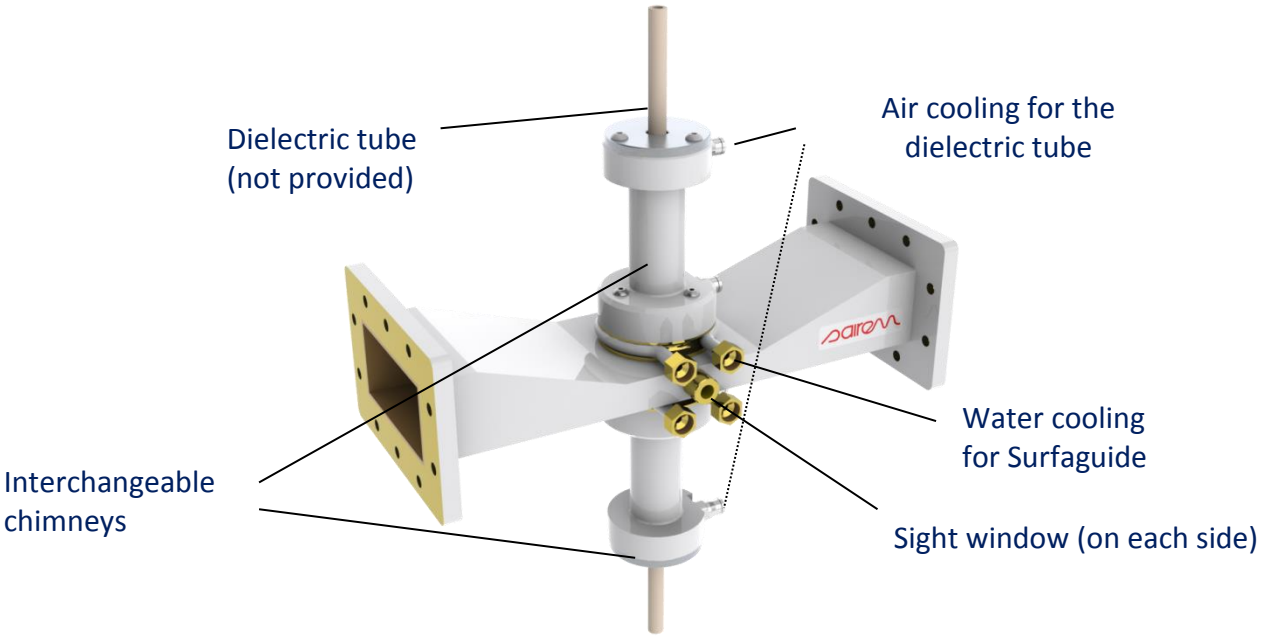
SURFAGUIDE WR340

SWPR WR340 3 XX

The Surfaguide is a waveguide-based electromagnetic-surface-wave launcher that allows sustaining long plasma columns using microwaves. The plasma is ignited and sustained in a dielectric tube that crosses a rectangular tapered WR340 waveguide. The reduction of the height of the WR340 waveguide allows to sustaining the plasma by increasing locally the microwave electric field, feature particularly important when working at atmospheric pressure and for external tube diameter that does not exceed 20 mm.
The Surfaguide is ideal for working in the atmospheric pressure range with dielectric tubes diameters between 10 and 20 mm and could equally work in the mbar range and down to a few 10^{-2} mbar.
The Surfaguide is designed to be used equally in R&D laboratories and industry for a very large range of applications. Typical applications of such source are atmospheric high temperature chemistry, nanopowder synthesis, surface activation, gas abatement, gasification, sterilization...

The Surfaguide could be used alumina tubes but other low loss, high temperature resistant dielectric materials could be used such as quartz, Pyrex™ or boron nitride. Inlet and outlet chimneys are designed to sustain and centre the dielectric tube. Moreover, in order to extend the operating conditions in the atmospheric pressure range and in the high power range, the dielectric tube has an air cooling possibility and the Surfaguide, water cooling.

Surfaguide plasma source WR340



Technical specification

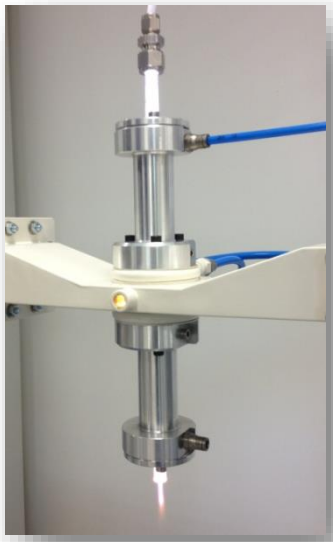
REF	SWPR WR340 3 XX
Frequency	2450 MHz ± 25 MHz
Microwave power	Max. 6 kW (depending of gas nature, pressure, dielectric tube diameter...)
Working pressure range	A few 10^{-2} mbar to atmospheric pressure
Connections	Standard WR340 flange (UG 553 A/U, RG 112/U)
Discharge tube external diameter	10 mm, 15 mm or 20 mm. MUST be specified when ordering **Tube not provided**
Cooling	Water, quick connectors for OD 8 mm hose Air, quick connectors for OD 6 mm tubing
Weight	cca 4.5 kg

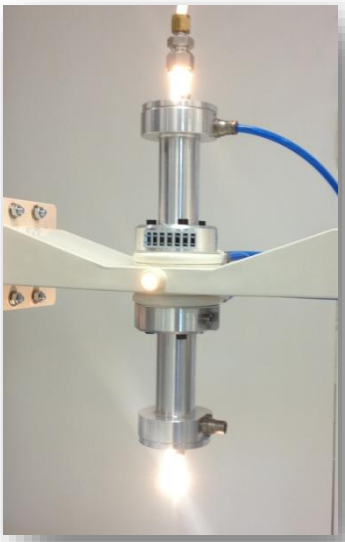
*XX = external diameter of the discharge tube

OBSERVATIONS

1. Inlet and outlet chimneys are interchangeable and matched to the external diameter of the dielectric tube; additional chimneys for tube diameters 10, 15 and 20 mm can be ordered;
2. The use of a microwave adapted window (alumina, quartz) between the microwave generator and the Surfaguide source is strongly recommended - to prevent accidental arcing travelling back to the magnetron and equally to act as a barrier/seal to protect the magnetron against any debris/corrosive agents that could escape from the plasma source and cause irreversible damage to the magnetron and isolator.

Argon and Oxygen plasmas with the Surfaguide at atmospheric pressure

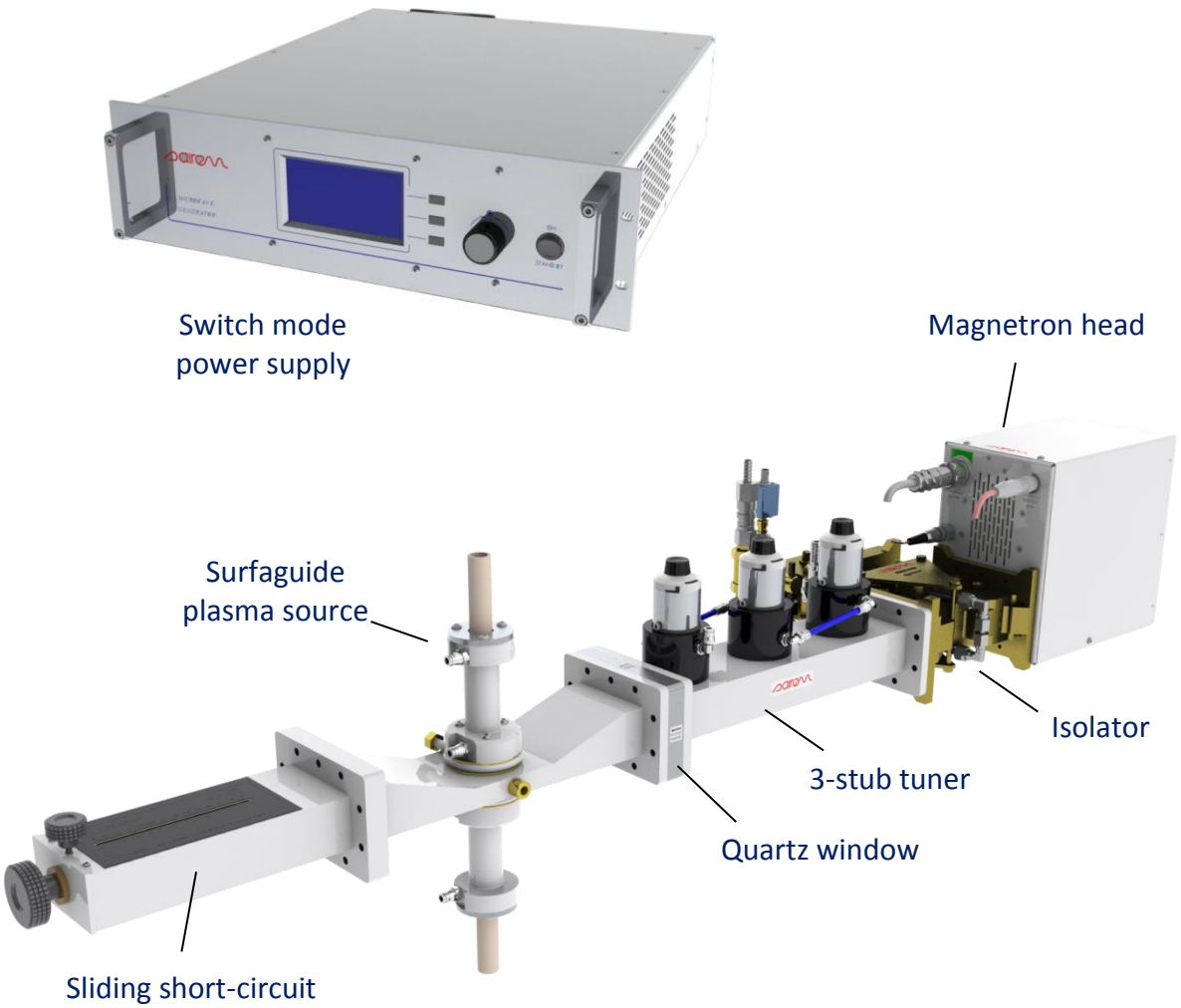


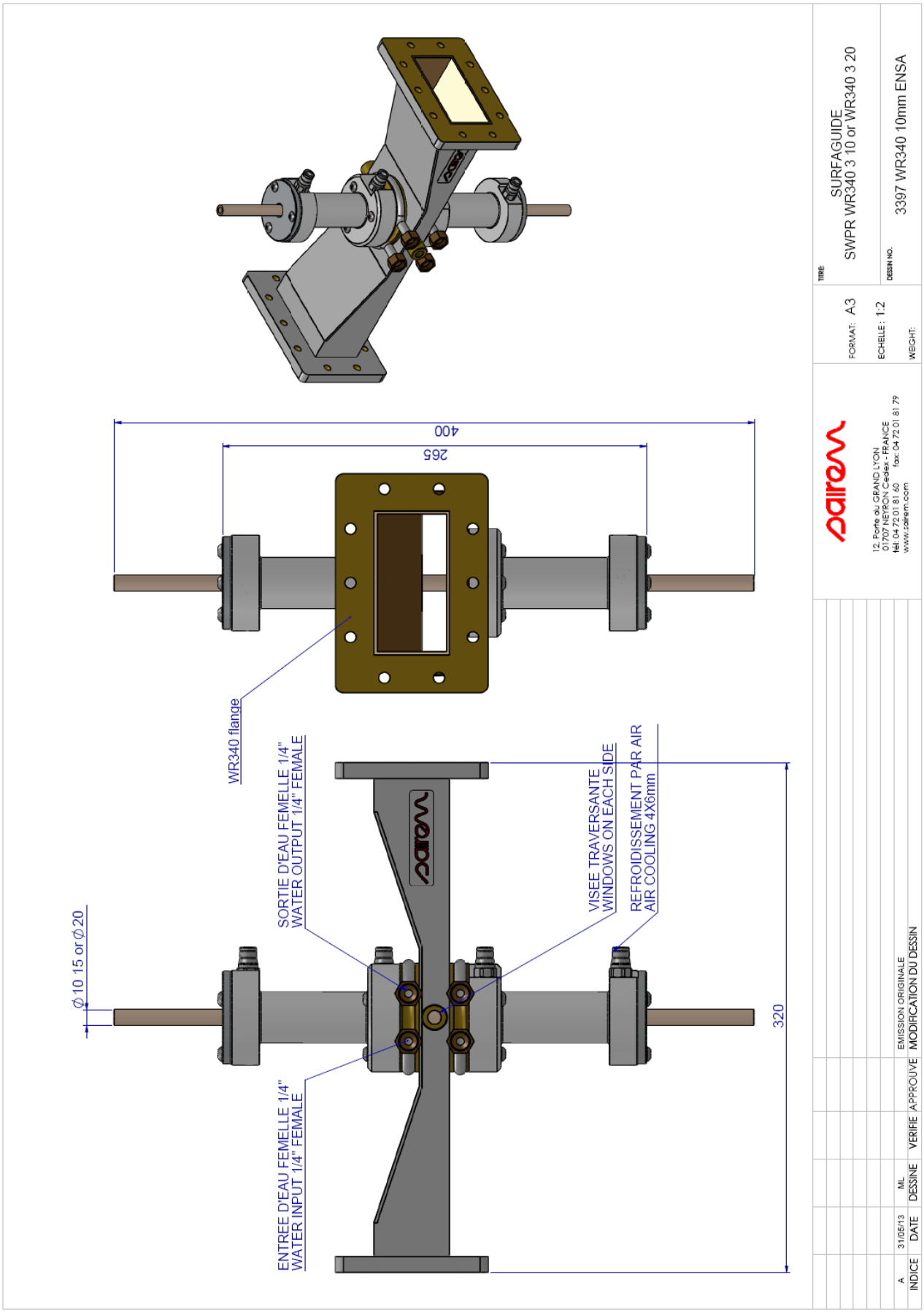


COMMON ASSEMBLY

The functionality of this plasma source is possible if the source is connected to a 2.45 GHz microwave generator (for the majority of applications 2 or 3 kW are enough) and means of impedance tuning, e.g. manual short circuit, 3-stub tuner, iris etc.

Standard Surfaguide set-up



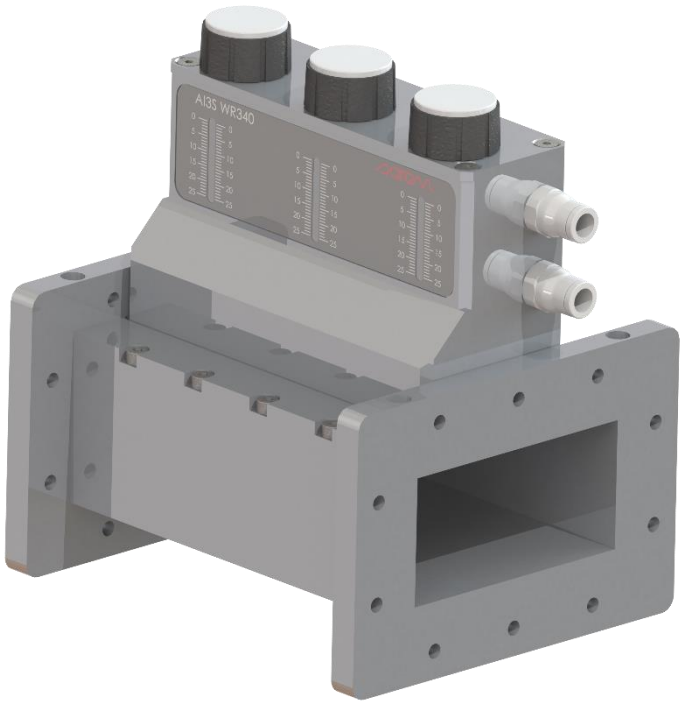

400
265
WR340 flange
SORTIE D'EAU FEMELLE 1/4"
WATER OUTPUT 1/4" FEMALE
VISEE TRAVERSANTE
WINDOWS ON EACH SIDE
REFROIDISSEMENT PAR AIR
AIR COOLING 4X6mm
Ø10 15 or Ø20
320
ENTREE D'EAU FEMELLE 1/4"
WATER INPUT 1/4" FEMALE
TITRE
SURFAGUIDE
SWPR WR340 3 10 or WR340 3 20
DESSIN NO.
3397 WR340 10mm ENSA
FORMAT: A3
ECHELLE : 1:2
WEIGHT:
sairem
12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com
INDICE
A
DATE
31/05/13
DESSINE
ML
VERIFIE
APPROUVE
EMISSION ORIGINALE
MODIFICATION DU DESSIN

AI3S NEW GENERATION MANUAL 3 STUB TUNER

The new AI3S generation is more efficient and adapted to generators up to 10 kW.

This impedance tuner is designed to decrease the level of reflected power in a microwave installation. The AI3S is designed to operate in conjunction with our 6 or 10 kW microwave generators, even in case of high SWR. This tuner can be used with a monomode or multimode cavities.

Its special design makes a micrometric adjustment of the stubs with display possible.



MAIN APPLICATIONS

ALL APPLICATIONS

- Reduce the reflected power in all microwave setups

KEY BENEFITS

DESIGN

- More compact
- Can substitute previous version, without changing the layout, with adaptation kits
- Asymmetric stubs mounting for optimal ease of use
- Optimized water cooling, with no risk of contamination

TECHNOLOGY

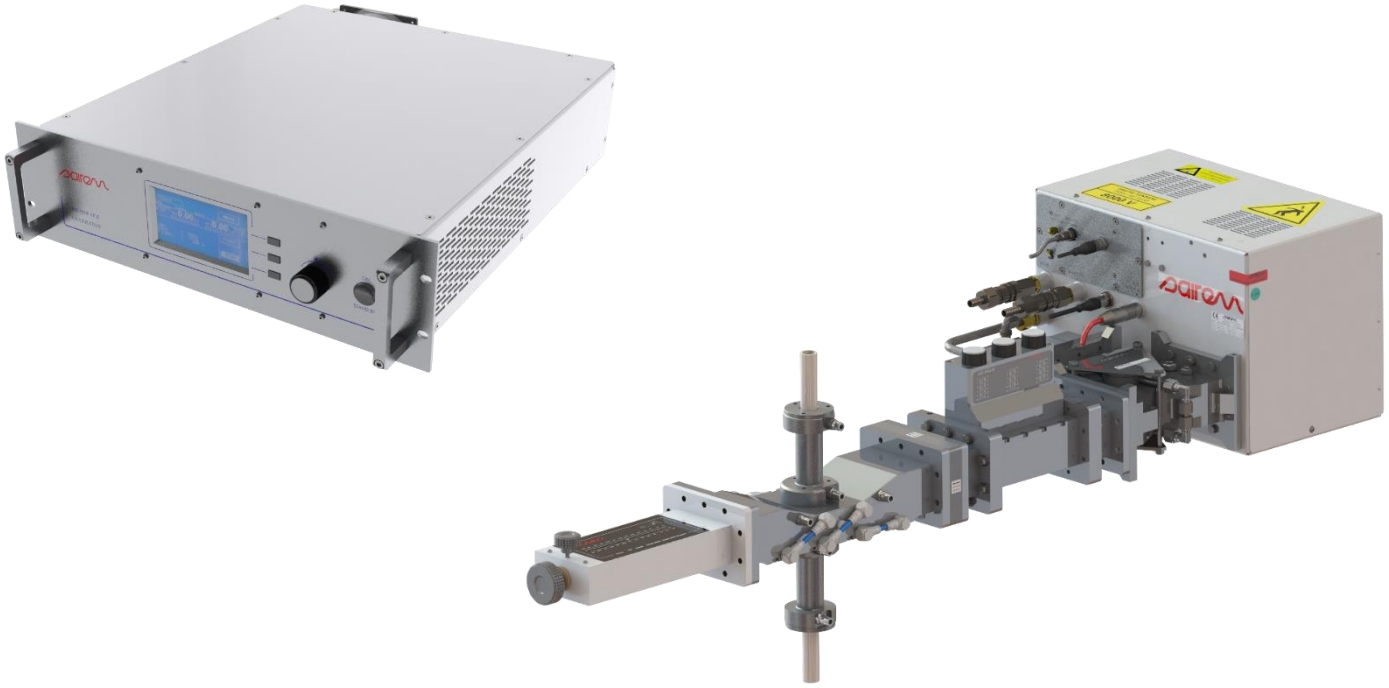
- 100 % reflected power acceptation with 6kW generator
- Lower heating of the equipment than previous version
- In 0 position the impedance tuner is equivalent to a standard waveguide

82 rue Elisée Reclus
69150 Décines-Charpieu
France
www.sairem.com
welcome@sairem.com
Tel: +33 472 018 160

AI3S NEW GENERATION
MANUAL 3 STUB TUNER

SETUP EXEXMPLE

2.45 GHz monomode set-up using surfaguide plasma source applicator



KEY SPECIFICATIONS

Reference	• **AI3SMWR340 NG**
Frequency	• 2450 MHz ± 50 MHz
Stub travel	• 25 mm, display on 25-turn fine tuning system

Power	• SWR[1] (Standing Wave Ratio) accepted and matched depending on microwave power and water flow:
	  ○ SWR accepted ≤ 6 at 6 kW without water
	  ○ SWR accepted ≤ 6 at 10 kW with 0.5 l/min
	• Impedance matching until SWR = 6 at 6 kW, until SWR = 5 at 10 kW

Output	• Flange UG 553 A/U (guide RG 112/U - WR340)
Cooling	• Water with ref ….2PE, 6 x 8 mm hose, min. 0.5 L/min above 6 kW, otherwise no need for water
Dimensions	• 177 x 160 x 138 cm (h x w x d)
Weight	• 3.3 kg
Material	• Aluminium

[1] **SWR or Standing wave ratio** is a measure of impedance matching of loads to the characteristic impedance of a transmission line or waveguide.

82 rue Elisée Reclus
69150 Décines-Charpieu
France
www.sairem.com
welcome@sairem.com
Tel: +33 472 018 160

OPERATING INSTRUCTIONS

Operating instructions with SAIREM microwave generators. For non-Sairem generators refer to the manufacturer's low power level recommendations.

- Once the experimental set-up is ready and the load is present in the applicator, turn on the microwave generator and set the forward power (FP) to a low level, for example 200 W for generators up to 3 kW and 600 W for the 6 kW generator.

- Using a microwave leakage meter, for example SAIREM's IFP05C, make sure there is no microwave leakage along the system. Pay special attention to all connections via flanges & bolts. Do not worry if during this test the FP = RP. Take your time, the magnetron is protected by a high-quality isolator rated 13 kW (6.5 kW FP and 6.5 kW RP).

- Push the microwave START button and note the levels of the forward (FP) and reflected power (RP) on the LCD display of the power supply. If the RP level is higher than 0 W use the sliding short circuit to lower it. Moving the sliding short circuit forward (towards the applicator) or backwards will increase or decrease the level of RP. Try to find the minimum RP possible;

- Increase FP to the desired level. Note the RP value and try to minimize it. Stop and block the position of the sliding short circuit when the minimum RP level has been reached;

- If the RP < 30 % FP and the sliding short circuit cannot lower it, start using the third stub of the 3-stub tuner (closest to the magnetron). Rotate it until the reflected power level is minimized. Do the same thing successively with the second stub alone, and with the first one alone. Identify the stub which has more influence on minimization between the first and the second stubs. Continue to minimize the reflected power by acting alternatively on this stub and the third one. If results are still unsatisfactory you can try to turn the position of the tuner in the microwave line at 180 degrees and start again.

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69150 Décines-Charpieu
France
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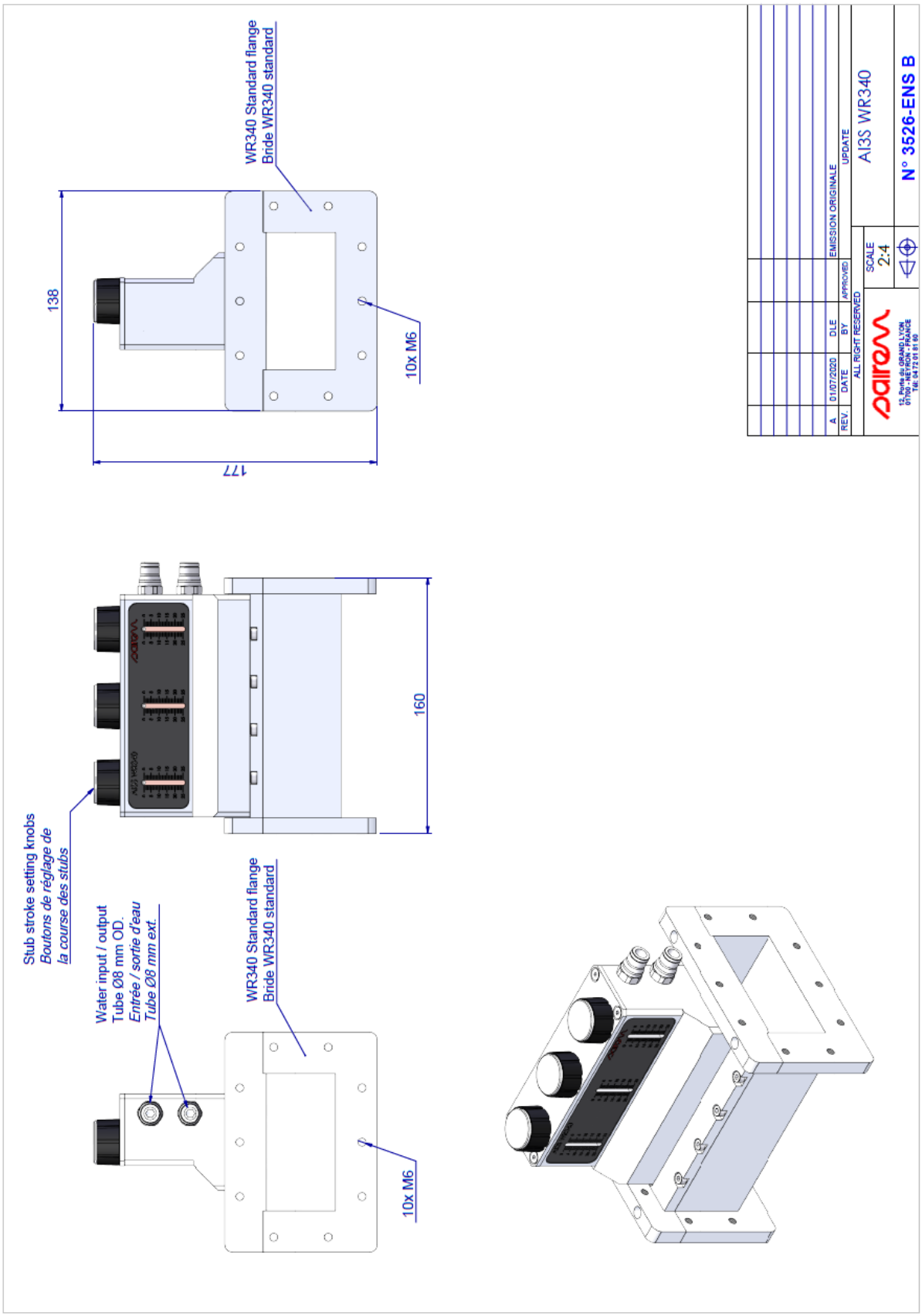
welcome@sairem.com
Tel: +33 472 018 160

MAIN DIMENSIONS



AI4S NG
AUTOMATIC 4 STUBS TUNER

AI4S is an automatic impedance tuner, equipped with 4 tuning stubs, impedance sensors, and an electronic control system. All the components are integrated in a standard waveguide. As soon as the generator delivers microwaves, the determinist auto tuner system matches instantaneously the load and permanently maintains the reflected power at a low level.

The tuner is specially designed with an efficient water-cooling system for high power applications, up to 10 kW.

SAIREM's **exclusive determinist tuner** adapts impedance automatically and much faster than the successive approximation technology often used.

MAIN APPLICATIONS

Plasma Applications

- PECVD Lab grown diamonds
- Any plasma application, particularly when change in operating conditions is requested

KEY BENEFITS

Design

- More compact than previous generation
- Can replace previous version

Technology

- Determinist auto tuner technology
- 100 % matching range up to Rho
- 100 % reflected power acceptation with 6 kW generator
- Less heating than previous version

82 rue Elisée Reclus
69150 Décines-Charpieu
France
www.sairem.com
welcome@sairem.com
Tel: +33 472 018 160

REMOTE CONTROL (option)

The AI4S automatic 4-stub tuner works in automatic mode if supplied with 24 V DC. The standard remote-control board is Modbus on RS232.

For additional manual control mode, for example to start at a specific stub position, several options are proposed:

1. Control using your own Labview program via Modbus on RS232 remote control (standard version)
2. Control using a PLC via PROFIBUS or CanOpen or Modbus Ethernet remote control
3. Control using SAIREM AI4S software which allows to switch between automatic and manual control of the impedance sensors at the click of a button. Another possibility is to record and export the position of sensors vs. time; for example, during change of operating condition.
4. Control using SAIREM CBA AI4S, consists of a 19 " 5 U control rack with integrated touch screen and 24 V DC power supply

Control of AI4S using SAIREM CBA AI4S

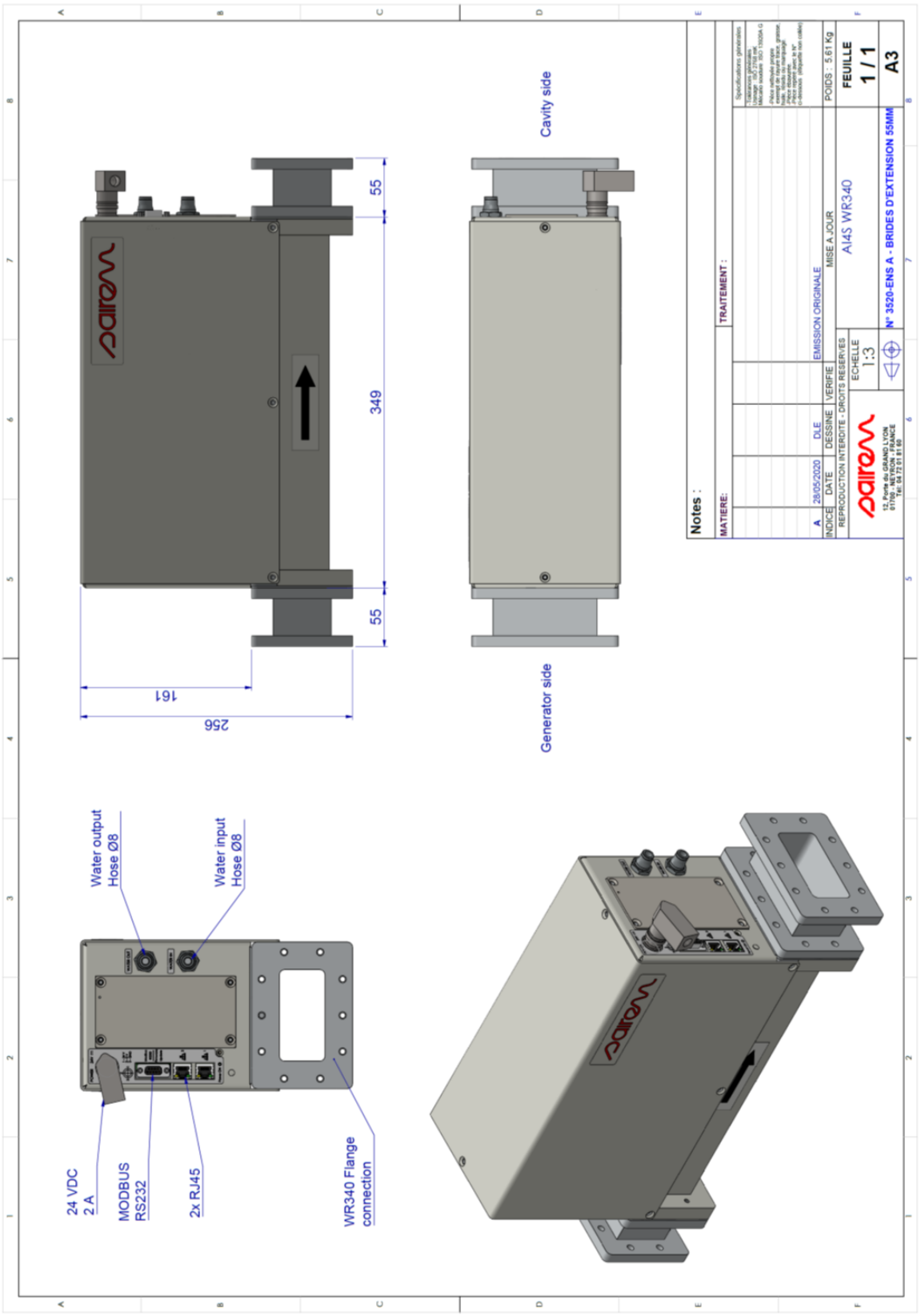
Control of AI4S using SAIREM AI4S software

AI4S NG
AUTOMATIC 4 STUBS TUNER

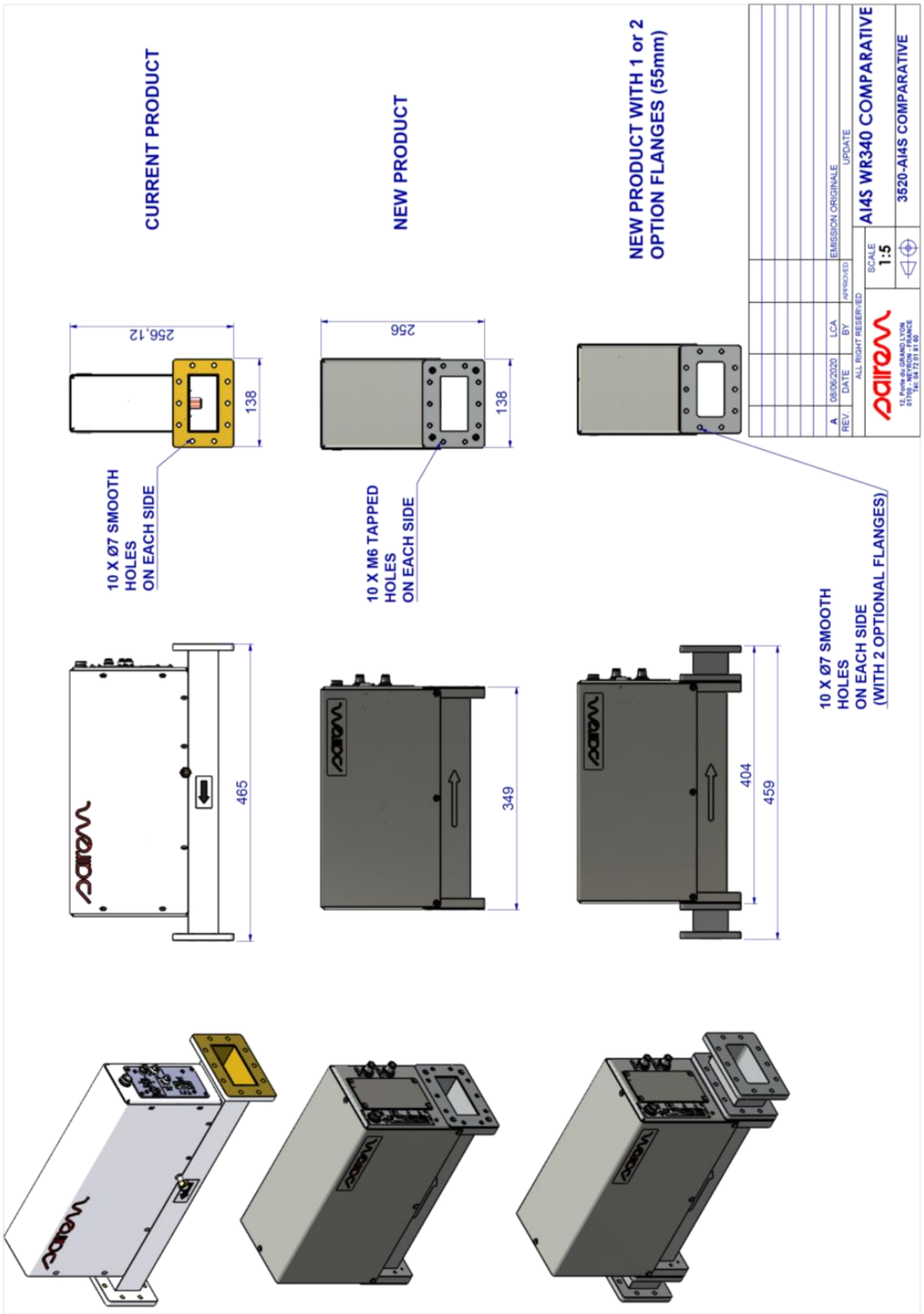
KEY SPECIFICATIONS

Reference	• **AI4SAWR340 NG MS A**
Description	• 2 pairs of 2-stub matching system, ¼ wavelength choke, integrated sensor consists of 4 diodes, X&Y remote giving the load impedance 'rho', manual or automatic control by the external connector
Frequency	• 2450 MHz ± 25 MHz
Max. input power	• 10 kW microwave power
Calibration	• Calibration is realized at the factory according to the generator's power, from 200 W to 10 kW (power must be indicated on order)
Impedance self-adjustment	• VSWR 5 max any phase, any power
Response time	• Maximum 3 s from any position
Neutral position	• During 10 s after switch on 24 VDC, the AI4S gets into neutral position (no matching effect) • If switch off into these 10 seconds period, the AI4S stays in this neutral position
Voltage	• 24 VDC 1.5 A (the power supply is not provided except if the AI4S is purchased with a control rack)
Power supply (option)	• Power supply not provided except if the AI4S is purchased with control rack ref. CBA AI4S
Wave guide	• WR340
Material	• Waveguide in aluminum, stubs in copper
Cooling (L/min)	• Water needed in some conditions • Min water flow 0 L/min 1 L/min 2 L/min For a 6 kW TOS < 6 TOS < 8 TOS < 10 For a 10 kW TOS < 3 TOS < 6 TOS < 10 (TOS = VSWR)
Remote control	• In option
Dimensions (L x W x H)	• 349 x 135 x 256 mm • 55 mm length for extension
Weight	• 5.6 kg for AI4S NG • 4.5 kg for CBA AI4S

MAIN DIMENSIONS



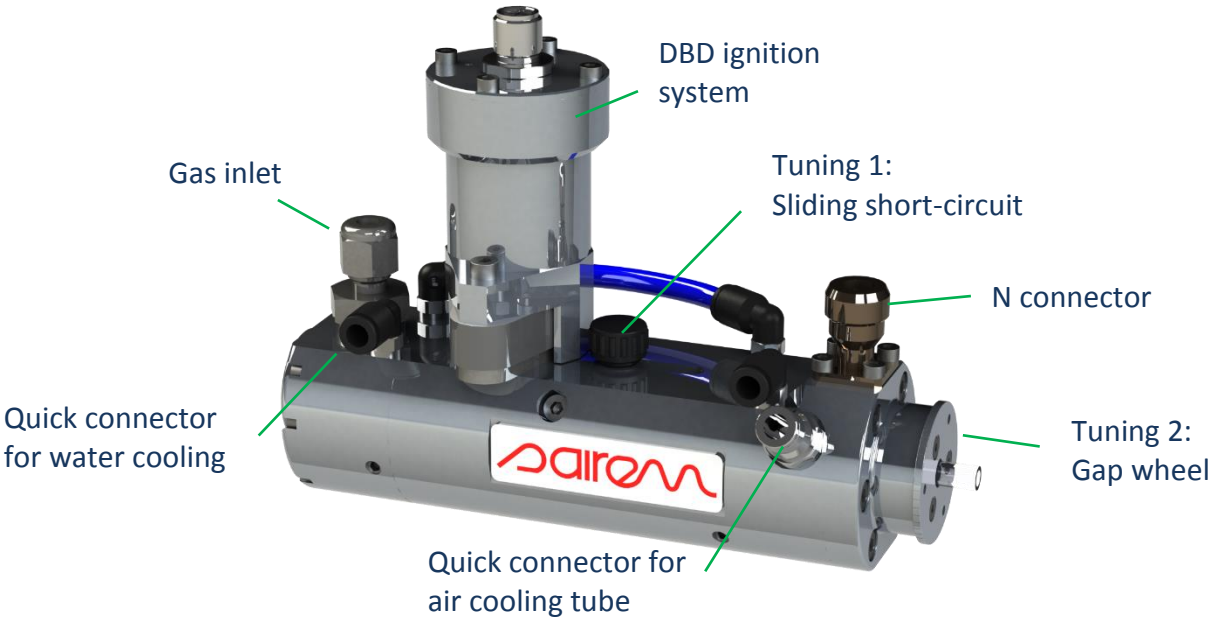
AI4S NG
AUTOMATIC 4 STUBS TUNER



S-WAVE

S-Wave (named after **Surface Wave plasma source**) is a compact plasma torch designed for industrial and laboratory applications that operates in the range of a few 10^{-2} mbar to atmospheric pressure. The plasma is created in a dielectric tube placed inside the source. The microwave electric field propagates longitudinally at the dielectric/plasma interface (plasma behaves as an electrical conductor). Radially the wave is strongly attenuated at skin depth. This principle allows to create and maintain plasma columns with lengths which depend on the operating pressure, microwave power and gas nature. The S-Wave can be efficiently applied to the production of reactive/excited species using dielectric tubes with diameters of 6 or 8 mm.

The S-Wave plasma source is inductively coupled, thus only two tuning adjustments are provided to match the impedance. Generally, nearly 0 % of reflected power is achieved using the integrated tuners. In addition, for given operator-set discharge conditions, the plasma is fully reproducible without any need for retuning at start-up. Quick connectors are integrated for water cooling and for gas connection. An optional **ignition system based on Dielectric Barrier Discharge** could be mounted in order to breakdown easily even at atmospheric pressure.



professional solutions

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When used for measurements and analysis, we recommend using Sairem's low ripple solid state microwave generator GMS 200 W in order to avoid spurious spectral lines resulting from the perturbations induced by 50/60 Hz mains electricity.

TECHNICAL SPECIFICATIONS

REF	S-WAVE 6, S-WAVE 8
Frequency	2450 MHz ± 50 MHz
Microwave power	Max. 200 W
Working pressure range	A few 10^{-2} mbar to atmospheric pressure
Discharge gas	Argon or argon-based gas mixture at atmospheric pressure. Pure argon for ignition at atm pressure. All gases at reduced pressure.
Discharge tube external diameter	6 or 8 mm. MUST be specified when ordering **2 quartz tubes of different lengths are provided**
Microwave connection	Via coaxial cable, N-type (female)
Cooling connections	Water, quick connectors for 6 mm OD hose Air, quick connectors for 6 mm OD tubing
Gas connection	Swagelok 6 mm connector
Ignition system	On demand – Argon flow should be high enough to allow ignition.
Weight	Approx. 500 g

OBSERVATIONS

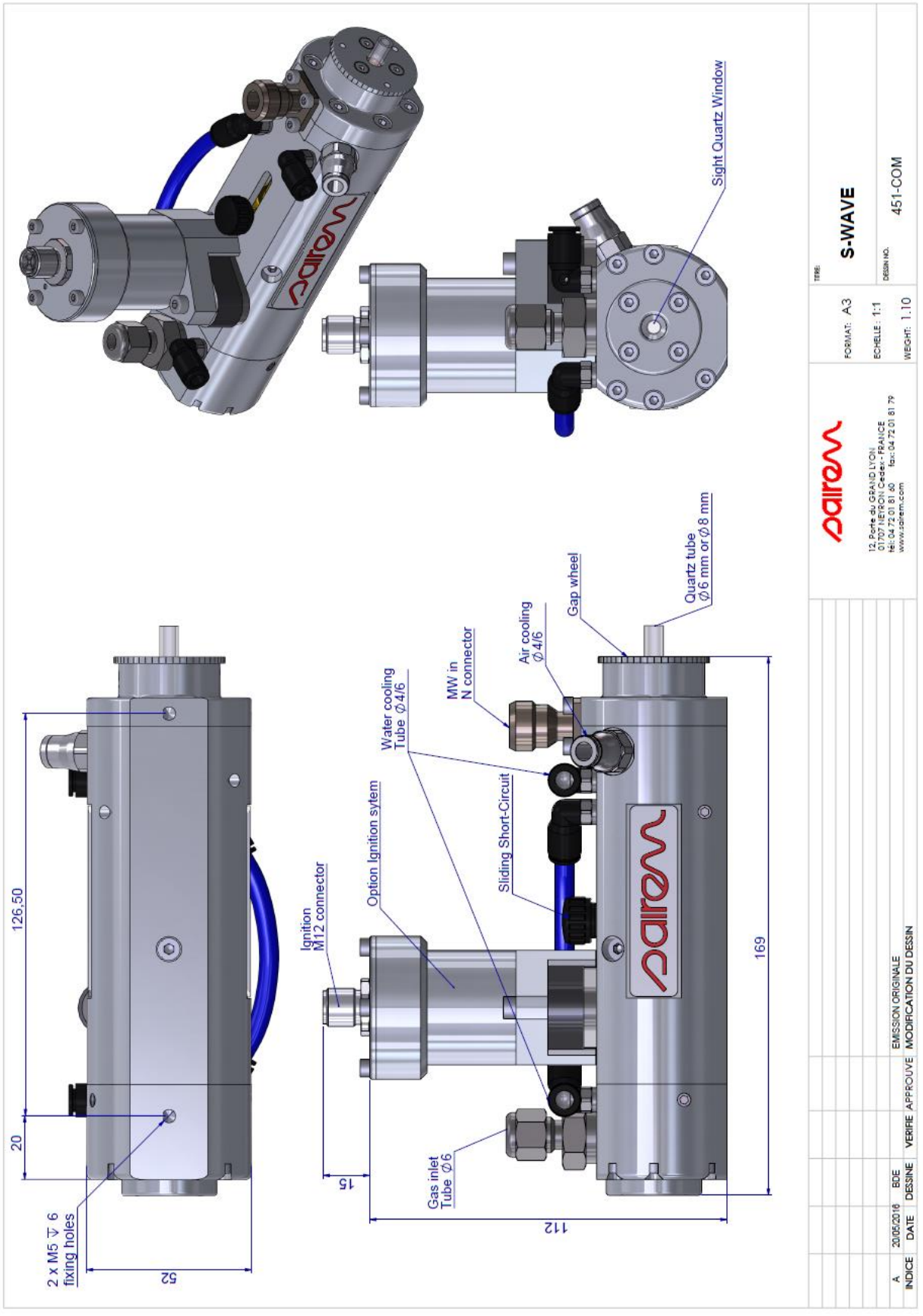
- At atmospheric pressure, air cooling of the tube is strongly recommended both to dissipate the heat and to favor plasma ignition.
- To move easily the sliding short circuit towards the nose, push the runner button and then move. To move towards the gas feeding pull the runner button and then move.
- To reduce the level of external microwave leakage, a small Faraday cage can be attached to the S-Wave via the two M6 bolts situated on the S-Wave's body. The cage should be long enough to enclose not only the plasma column but also the dielectric tube in its full length.

COMMON ASSEMBLY

200 W solid state generator

N coaxial cable

S-Wave


Sight Quartz Window
Quartz tube
Ø6 mm or Ø8 mm
Gap wheel
Air cooling
Ø4/6
MW in
N connector
Water cooling
Tube Ø4/6
Option Ignition sytem
Sliding Short-Circuit
Ignition
M12 connector
Gas inlet
Tube Ø6
169
112
15
126,50
20
2 x M5 ↧ 6
fixing holes
52
S-WAVE
451-COM
FORMAT: A3
ECHELLE: 1:1
WEIGHT: 1.10
12, Porte du GRAND LYON
01700 NEYRON - France
tél: 04 72 01 81 80
fax: 04 72 01 81 79
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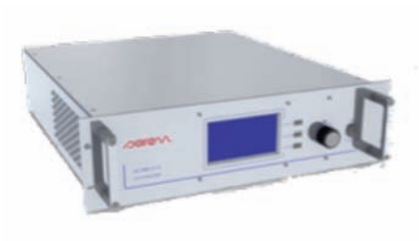
2450 MHz GENERATORS

2450 MHz, 200 W SOLID STATE GENERATORS

SAIREM's solid state generators are microwave generators at 2450 MHz. They provide a continuous wave (CW) output power adjustable from 0 to 200 W at frequencies ranging between 2425 MHz and 2475 MHz (version with variable frequency, VF).



In comparison with magnetron generators, the main advantages of the solid state generator are:

- Very good (narrow and stable) frequency spectrum even at low power;
- True RMS detector with linear measurement of reflected and forward power;
- No electronic tube (magnetron) and no high voltage inside the generator (longer life time and safer);
- Possibility to adjust the frequency.

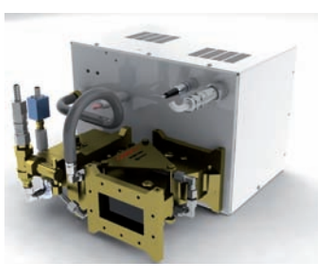
GENERATORS 2450 MHz, MAGNETRON 2000 W TO 30 kW

This generator consists of a switch mode power supply. The digital electronic control drives simultaneously anodic current, electromagnet (HV) and filament. The result is a very low power setting possibility, maximum efficiency, reduced ripple and increased magnetron life time.

The filament soft start function also contributes to increase magnetron life time.

Available options:
- Internal pulse (KIP)
- Control solftware Labview
- Standard cable length: 4 m (up to 25 m on request)
- HV transformer for industrial applications (heating)

Available powers: 2 kW – 3 kW – 6 kW – 15 kW – 30 kW



COMPACT HEATING GENERATORS 2450 MHz, MAGNETRON 1200 W AND 2000 W

It is specially designed for applicators with low Q factor such as:
- Multimode cavity for static or continuous treatment,
- Radiating waveguide with slots or antennas,
- Monomode cavity with high load.

The MMP12 operates at the ISM frequency band (Industrial, Scientific and Medical) at 2450 MHz.
Available powers: 1200 W & 2000 W
Special configurations on request.

896 / 915 / 922 MHz GENERATORS

This generator consists of a switch mode power supply and an integrated or separated microwave head. The digital electronic control drives simultaneously anodic current, electromagnet (HV) and filament. The result is very low power setting possibility, maximum efficiency, reduced ripple and increased magnetron life time.

The filament soft start function also contributes to increase magnetron life time.

Available options:

- Internal pulse (KIP)
- Control solftware Labview
- HV transformer for industrial applications (heating)

Available powers: 5 kW – 18 kW – 36 kW – 54 kW – 72 kW – 100 kW

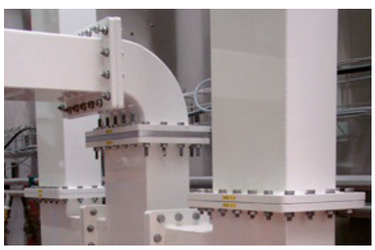
KLYSTRON OR GYROTRON GENERATORS

10 - 14 - 18 GHz (KLYSTRON)
24 - 28 GHz (GYROTRON)

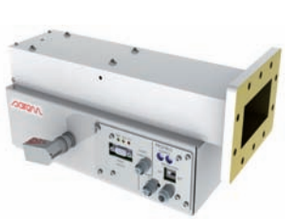
With its characteristics of power stability whatever the load, very fast response time when pulsed (via external modulated signal), low ripple, spectral quality, degree of protection and reliability, SAIREM's klystron/gyrotron generator is a high-performance device designed for high-performance applications and particularly for ions sources.

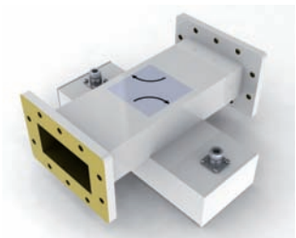
2450 MHz WAVE GUIDE COMPONENTS

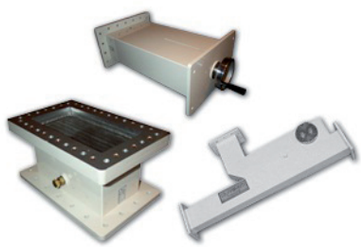
SAIREM manufacturers a large variety of microwave components for the transmission, measurement and tuning of microwave energy.



- Tuners manual & automatic
- Flanges
- Water loads & dry loads
- Bends
- Couplers
- Windows
- Isolators
- Sliding short-circuits
- Transitions







SAIREM's R&D team can also design structures that are application specific. SAIREM can organize standard or tailored microwave training courses.

MICROWAVE LEAKAGE METERS

Sairem has developed portable equipment for measurement and test:

- Measurement of microwave leakage level 2.45 GHz
- Wall-mount microwave surveymeter 2.45 GHz or 915 MHz.

These apparatus are especially appreciated by the service engineers while performing maintenance tasks and fault finding.

915 MHz MICROWAVE LEAKAGE METER

IFP 915 D

The IFP 915 D detects and measures the power density lost externally by microwave equipment (domestic ovens, laboratory or industrial equipment).
The IFP 915 D is handheld and operates without battery. The microwave leakage is shown on a display graduated in mW/cm².
To make sure that a measurement is carried out correctly and according to legislation, the detector has a built-in spacer (plastic triangle) with a total height of 5 cm.

Technical specification

REF	IFP 915 D
Frequency	915 MHz
Graduation*	0 to 2.3 mW/cm^2
Precision	5 % at full scale, 10 % on linearity
Size	Detector 26 mm x 72 mm x 142 mm Delivered in a case size 230 mm x 190 mm x 45 mm
Total weight	390 gr

* CE Directive 2013-35-UE states max. acceptable microwave leakage level of 23 W/m^2, i.e. 2.3 mW/cm^2 measured at 5 cm from the equipment.

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2450 MHz MICROWAVE LEAKAGE METER

IFP 2450 D

The IFP detects and measures the power density lost externally by microwave equipment (domestic ovens, laboratory or industrial equipment).
The IFP is handheld and operates without battery. The microwave leakage is shown on a display graduated in mW/cm².
To make sure that a measurement is carried out correctly and according to legislation, the detector has a built-in spacer (plastic triangle) with a total height of 5 cm.

Technical specification

REF	IFP 2450 D
Frequency	2450 MHz
Graduation*	0 to 5 mW/cm^2
Precision	5 % at full scale, 10 % on linearity
Size	Detector 26 mm x 72 mm x 142 mm Delivered in a case size 230 mm x 190 mm x 45 mm
Total weight	350 g

* CE Directive 2013-35-UE states max. acceptable microwave leakage level of 50 W/m^2, i.e. 5 mW/cm^2 measured at 5 cm from the equipment.

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WALL-MOUNT 915 MHz MICROWAVE SURVEYMETER
Ref. DFM L24DC

The microwave survey meter DFM L24DC 915 MHz is a system designed to measure and alarm if microwave leakage is detected in the immediate vicinity of a microwave system (industrial microwave oven, laboratory & industrial installations). The DFM L24DC is to be fixed on a wall, up to 20 m from the system to be surveyed.

To adjust its sensitivity of detection, the DFM must be positioned in the vicinity of the equipment to be surveyed on which, a microwave leakage of 2.3 mW/cm^2 has to be produced. After the adjustment of the sensitivity, if a leakage higher than 2.3 mW/cm^2 is detected, the DFM will alert by light and sound; also, the DFM can be used as an interlock which will stop the microwave transmission (if contact linked). The reset of the DFM can be done via its own reset button or by cutting the power off.

! **Obs**. The DFM L24DC is a microwave survey meter; for leakage metering please use a 915 MHz microwave leakage meter.

Technical specification

REF	DFM L24DC
Frequency	915 MHz (integral band filter from 902 to 928 MHz) 896 MHz available on request
Detection distance	Adjustable for a microwave leakage of 2.3 mW/cm² at distance up to 20 m; delivery preset 2.3 mW/cm^2 at 5 m CE Directive 2013-35-UE states max. microwave leakage level of 23 W/m^2, i.e. 2.3 mW/cm^2
Mains	24 VDC, consumption 2 mA in stand-by mode, 50 mA in detection mode
Connectors	M12A, female 5 pins, for M12 standard cables, 10 m standard length (20 m optional) 2 terminals for 24 VDC, 3 terminals to contact alarm
Contacts	1 inverter, power cut-off 1 A at 24 VDC
Dimensions	160 mm x 110 mm x 62 mm, weight 350 g
Wall fixing	Base to fix on the wall with 2 screws (not provided); upper block mounts on the base through bayonet-type system - see drawing.

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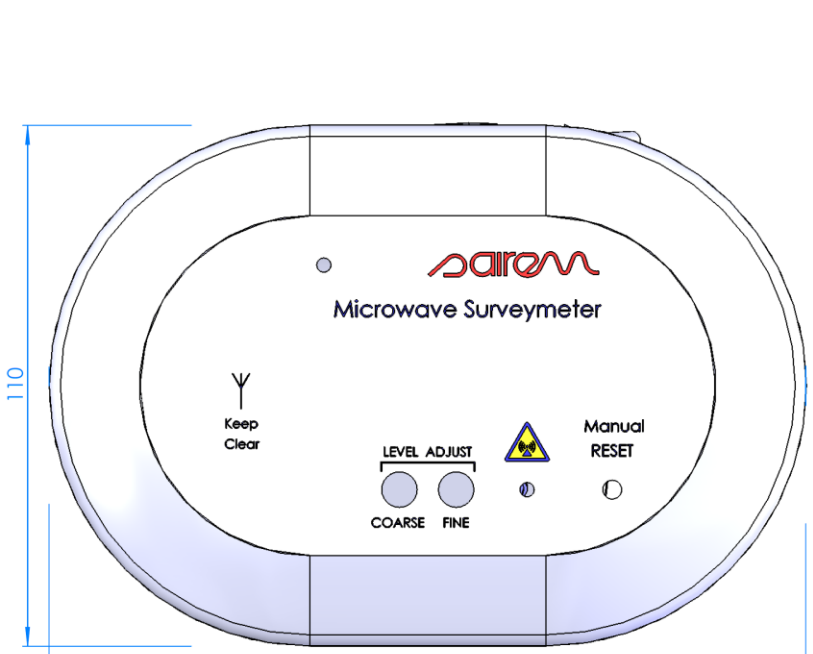

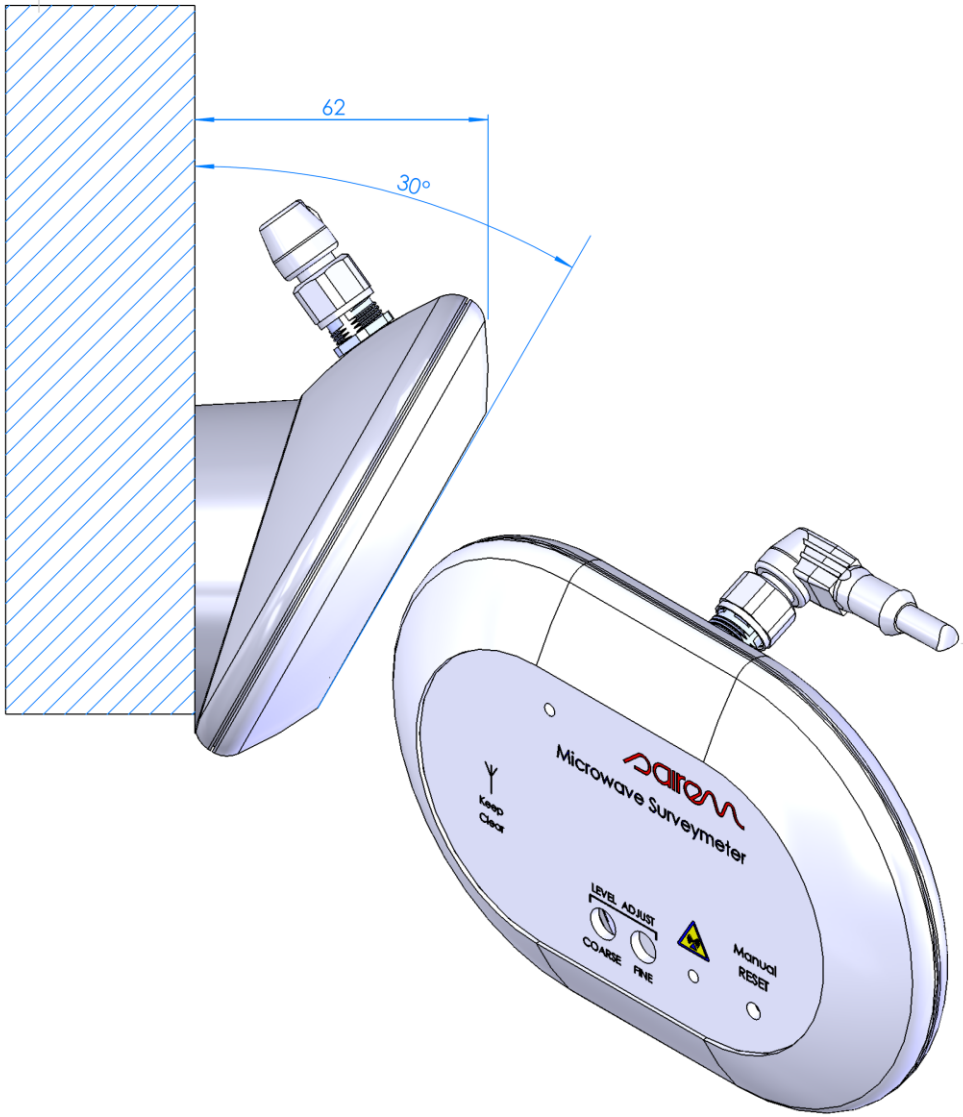

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FORMAT: A3

ECHELLE : 1:1

WEIGHT: 0.09

TITRE:

SURVEY METER
DETECTEUR DE FUITES
DFML24DC / DFMM24DC

DESSIN NO. 3286-ENS

INDICE DU DOCUMENT

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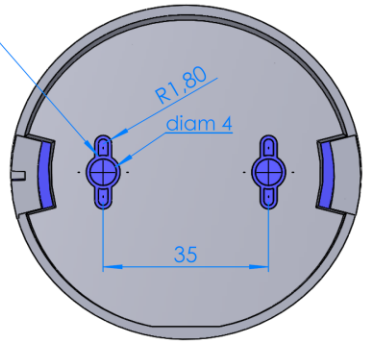
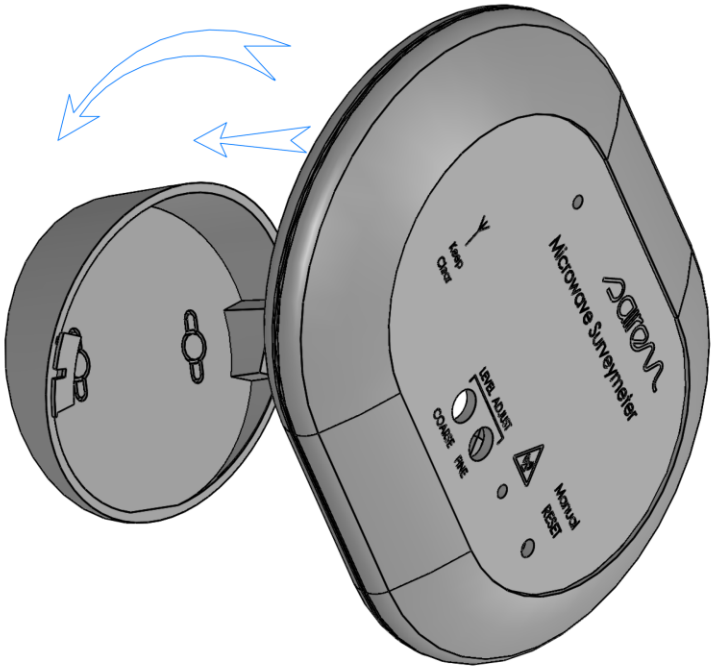
2 ∅ 4



ASSEMBLY PRINCIPLE
PRINCIPE DE MONTAGE



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FORMAT: A3

ECHELLE : 1:2

WEIGHT:

TITRE:

DFM ASSEMBLY PRINCIPLE
MODE DE FIXATION DU BOITIER DFM

DESSIN NO. 3286-COM 2

INDICE DU DOCUMENT

WALL-MOUNT 2450 MHz MICROWAVE SURVEYMETER
Ref. DFM M24DC

The microwave survey meter DFM M24DC 2450MHz is a system designed to measure and alarm if microwave leakage is detected in the immediate vicinity of a microwave system (domestic microwave oven, laboratory & industrial installations). The DFM M24DC is to be fixed on a wall, up to 20 m from the system to be surveyed.

To adjust its sensitivity of detection, the DFM must be positioned in the vicinity of the equipment to be surveyed on which, a microwave leakage of 5 mW/cm^2 has to be produced. After the adjustment of the sensitivity, if a leakage higher than 5 mW/cm^2 is detected, the DFM will alert by light and sound; also, the DFM can be used as an interlock which will stop the microwave transmission (if contact linked). The reset of the DFM can be done via its own reset button or by cutting the power off.

! **Obs**. The DFM M24DC is a microwave survey meter; for a microwave leakage meter please see our handheld IFP 2450 MHz.

Technical parameters:

REF	DFM M24DC
Frequency	2450 MHz +/- 50 MHz (integral filter)
Detection distance	Adjustable for a microwave leakage of 5 mW/cm² at distance up to 20 m; delivery preset 5 mW/cm^2 at 5 m CE Directive 2013-35-UE states max. microwave leakage level of 50 W/m^2, i.e. 5 mW/cm^2
Mains	24 VDC, consumption 2 mA in stand-by mode, 50 mA in detection mode
Connectors	M12A, female 5 pins, for M12 standard cables, 10 m standard length (20 m optional) 2 terminals for 24 VDC, 2 terminals to contact alarm
Contacts	1 inverter, power cut-off 1 A at 24 VDC
Dimensions	160 mm x 110 mm x 62 mm, weight 350 g
Wall fixing	Base to fix on the wall with 2 screws (not provided); upper block mounts on the base through bayonet-type system - see drawing.

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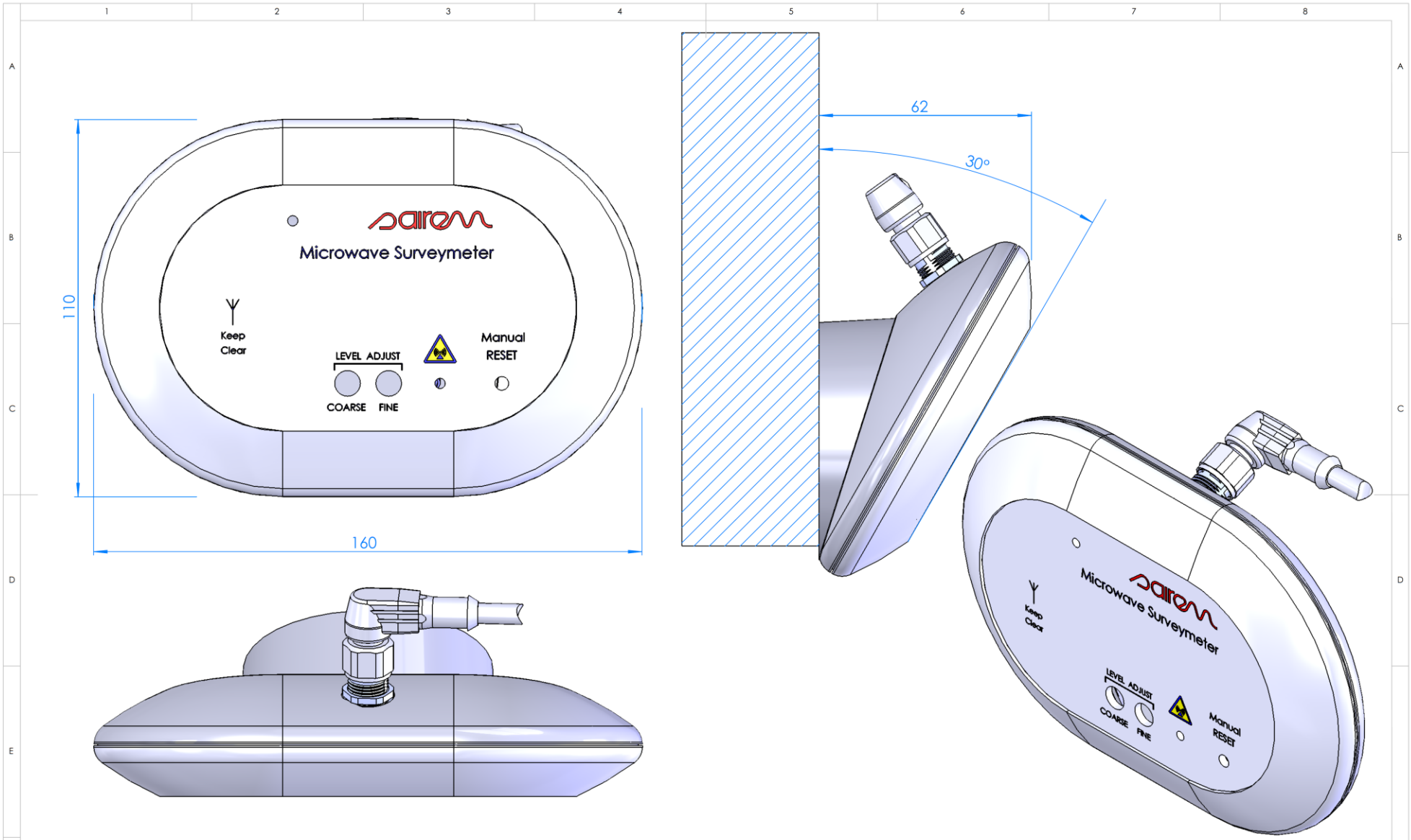

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tél: 04 72 01 81 60 fax: 04 72 01 81 79

FORMAT: A3

ECHELLE : 1:1

WEIGHT: 0.09

TITRE:

SURVEY METER
DETECTEUR DE FUITES
DFML24DC / DFMM24DC

DESSIN NO. 3286-ENS

INDICE DU DOCUMENT

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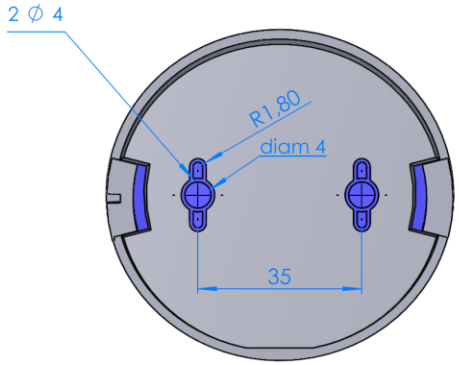
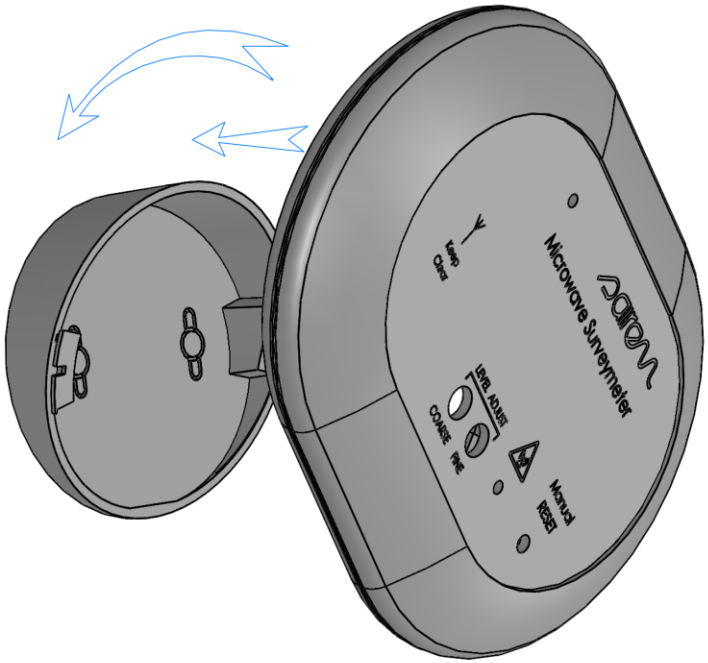


ASSEMBLY PRINCIPLE
PRINCIPE DE MONTAGE



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FORMAT: A3
ECHELLE : 1:2
WEIGHT:

TITRE:
DFM ASSEMBLY PRINCIPLE
MODE DE FIXATION
DU BOITIER DFM

DESSIN NO. 3286-COM 2

INDICE DU DOCUMENT

13.56 & 27.12 MHz
RADIO FREQUENCY GENERATORS

SAIREM has been developing RF generators for more than 30 years; at present, our RF generators are available at power levels from a few watts up to 50 kW. Their high reliability and quality is recognized and appreciated by industrial customers and research laboratories worldwide.

The modern design allows the integration of these generators in a high variety of applications.
We offer custom made RF generators.

Available frequencies: 13.56 and 27.12 MHz

Available powers: 1.2 kW - 2.4 kW - 20 kW - 30 kW - 50 kW

MINILABOTRON 2000, 2 kW, 2450 MHz

The Minilabotron 2000 is an easy-to-use microwave-assisted reactor, engineered as a system specifically designed for the laboratory use (chemistry, biochemistry etc.) Figs. 1a & 1b.

Fig. 1a. Minilabotron 2000 and support (option)

The Minilabotron 2000 has the flexibility to meet all laboratory requirements; the system can be easily configured to perform different applications including reactions in liquid phase, solid phase and gas phase in homogeneous and heterogeneous mixtures.

The Minilabotron 2000 is constructed of high-grade stainless steel, with high degree of finishing, i.e. inside and outside surfaces are covered by a non-corrosive, high impact resistant resin layer.

The double jacket of the oven allows the operation of the reactor at very high temperature whilst the outside of the oven remains at room temperature.

The microwave cavity is designed and dimensioned to provide a very uniform microwave field.

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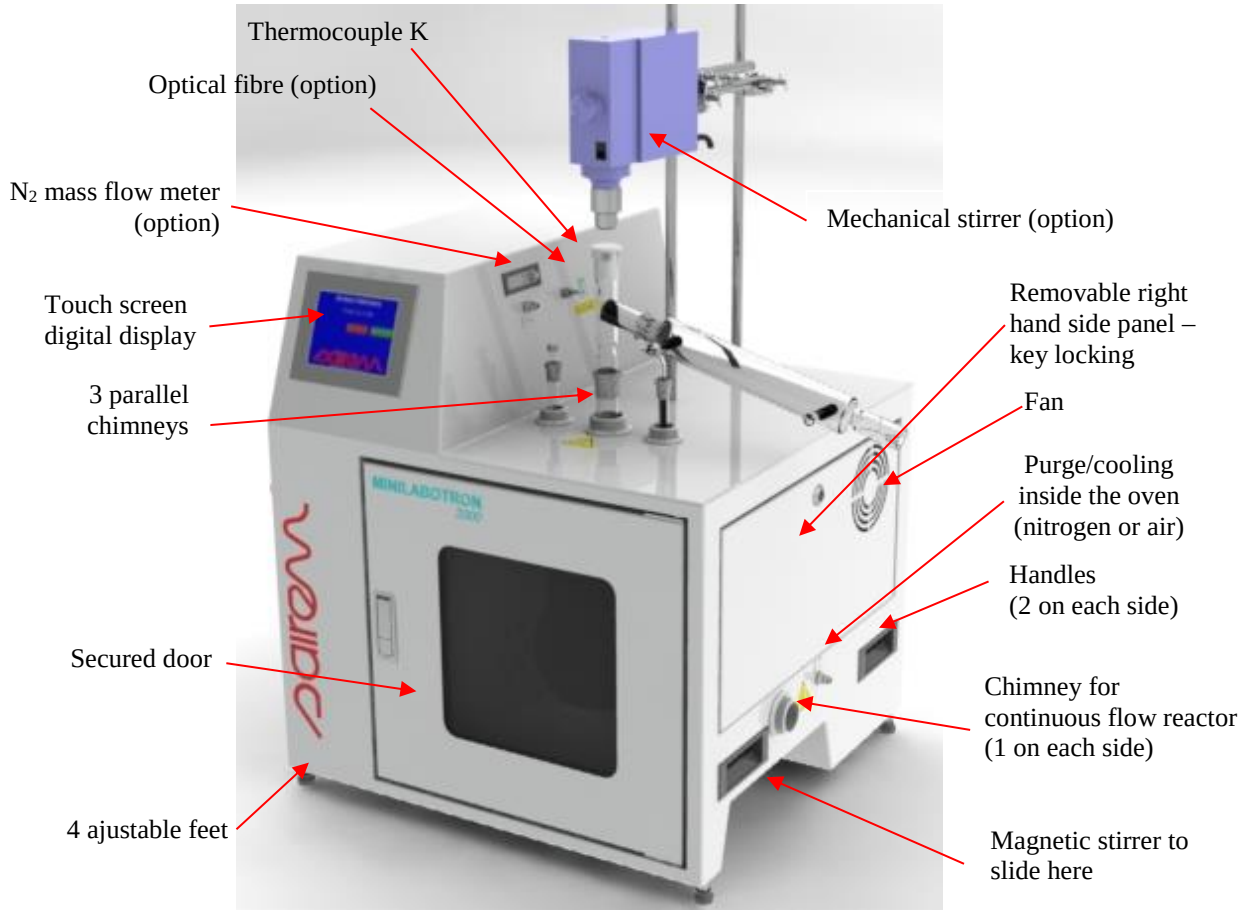

Fig. 1b. Minilabotron 2000

The reliable operation of the magnetron, i.e. the electronic tube that produces microwaves, is assured by an integrated isolator and control of reflected power.

The continuous control and monitoring of the forward power, reflected power & temperature are achieved via an integrated PLC/digital display.

The Minilabotron 2000 can be used with batch reactors - Fig. 2a and equally with continuous flow reactors - Figs. 2b; the connectivity of these reactors does not require tools.

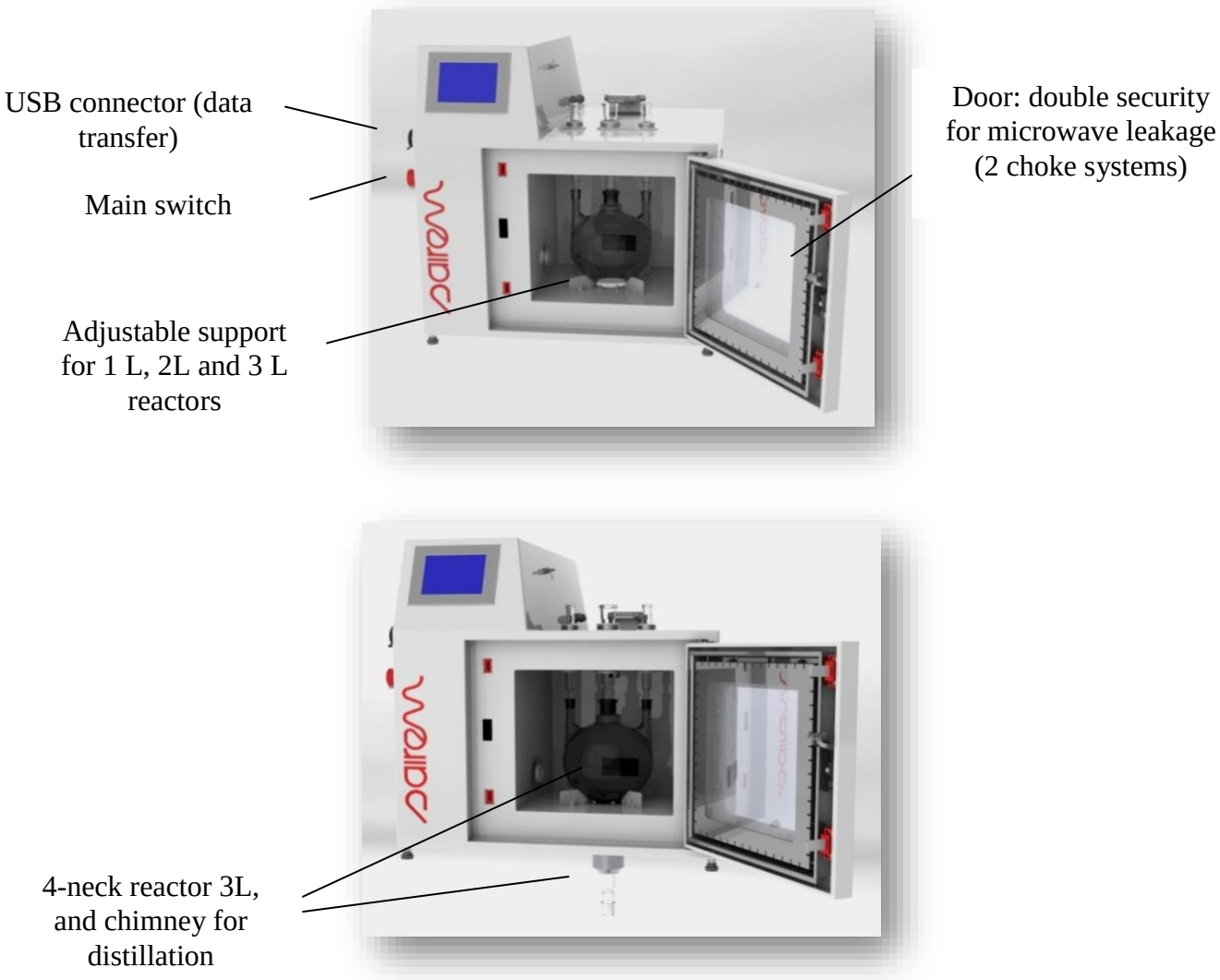

Fig. 2a. Minilabotron 2000 with batch reactors 3 L (3-neck or 4-neck)

central joint NS 29/32F, lateral joints NS 19/23F) & 4-neck (3 necks on top and 1 neck on bottom, NS 29/32M)

The temperature measurement is performed both via IR – temperature measurement inside the oven (batch and continuous flow reactors) and thermocouple – outside the microwave cavity, at the exit of the continuous flow reactor; an inside-reactor optic fibre temperature measurement (for temperatures up to 250 ^{0}C) can be also ordered as an option.

The batch reactor features stirring system either by mechanical stirrer (to be mounted at the upper part of the batch reactor) or by magnetic stirrer (through the lower part of the oven) – not supplied.

The continuous flow reactor features SAIREM's innovative SPIN, Fig. 2c, reactor proven to improve yield, selectivity and safety of liquid-liquid and liquid-vapour reactions.

For protection against splashing, all the connections with the reactor are made inside the microwave cavity and accessible from outside the system; for all cases involving the use of highly volatile molecules, the Minilabotron 2000 is equipped with continuous gas purging via ¼'' NPT.

The small footprint makes the Minilabotron 200 easily integral within a laboratory standard fume hood.

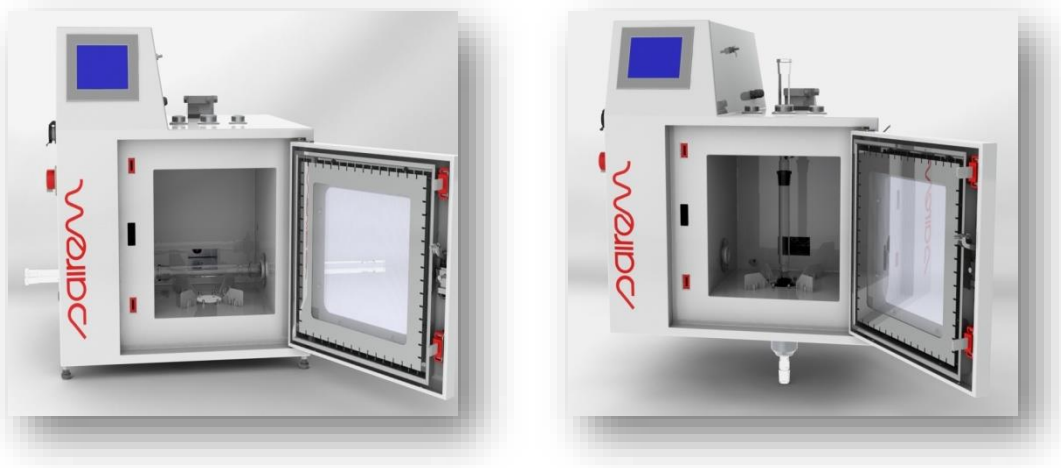

Fig. 2b. Minilabotron 2000 with column type reactor or SPIN – horizontal and vertical, 2 joints NS 29/32M

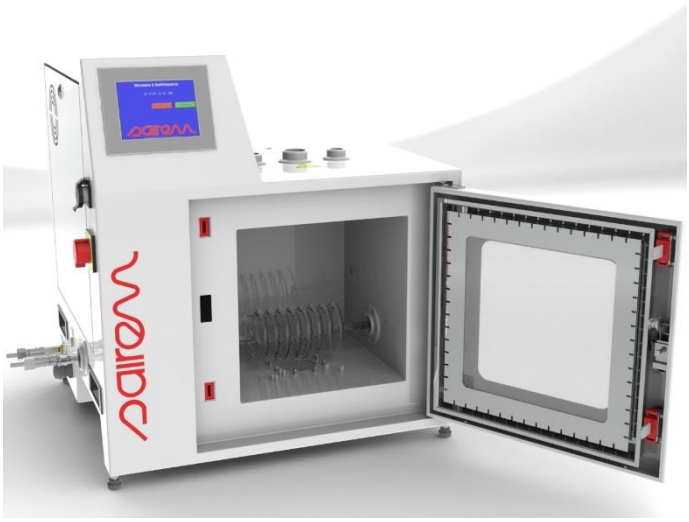

Fig. 2c. Minilabotron 2000 with SPIN type reactor – horizontal, 2 joints NS 14/23M (internal V ~ 200 mL)

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MAIN TECHNICAL PARAMETERS

REF.	MINILABOTRON 2000
Microwave frequency	2450 MHz
Maximum power	2 kW continuous wave (CW), adjustable from 0 to 2 kW with 10 W step; pulsed function in option
Microwave cavity	Stainless steel, anti-corrosive paint inside and outside Dimensions: 300 x 300 x 300 mm
Doors	¼ wave choke, double safety closed system, sight window and LED illuminated inside
Safety	Door double security by contact; Reflected power limitation by PLC and bidirectional coupler; Temperature sensors inside the microwave cavity; Internal gas purging ¼'' NPT; Reactor connections made inside the microwave cavity via standard cone connections (tool-free); 'Beep' system for signalling end of reaction time Microwave cavity purge (compressed air etc.)
Temperature control	IR (from -30 to 950 ^{0}C) & thermocouple (type K, Inconel, up to 900 ^{0}C) or optic fibre (from -80 to 250 ^{0}C)
Gas addition (in to reactor)	Integrated mass flow meter & electromagnetic valve 0.2 – 10 L/min – option
Reactors (Pyrex)	Batch or continuous flow SPIN or column type: • Batch 3-neck flask: top lateral parallel joints NS14/23F and central joint NS 29/32F; • Batch 4-neck flask: top lateral parallel joints NS14/23F and central joint NS 29/32F, bottom central joint NS 29/32M; • Column reactor (diam. 40 mm, L = 275 mm): 2 joints NS 29/32M. • SPIN reactor: 2 joints NS 14/23 =M
Reactor stirring	Magnetic or mechanical (via NS 29/32F joint) – stirrers not provided
Control	Forward power, reflected power, time and temperature via integral PLC/digital display.
Electrical requirements	208/230 VAC, 60 Hz ; 220/240 VAC, 50 Hz 20 A
Magnetron cooling	Water, 2 L/min, with integrated electro-valve for control
Max. overall dimensions (H x L x W) with connectors, weight	700 x 580 (1000)* x 700 mm, 70 kg

*With front door opened

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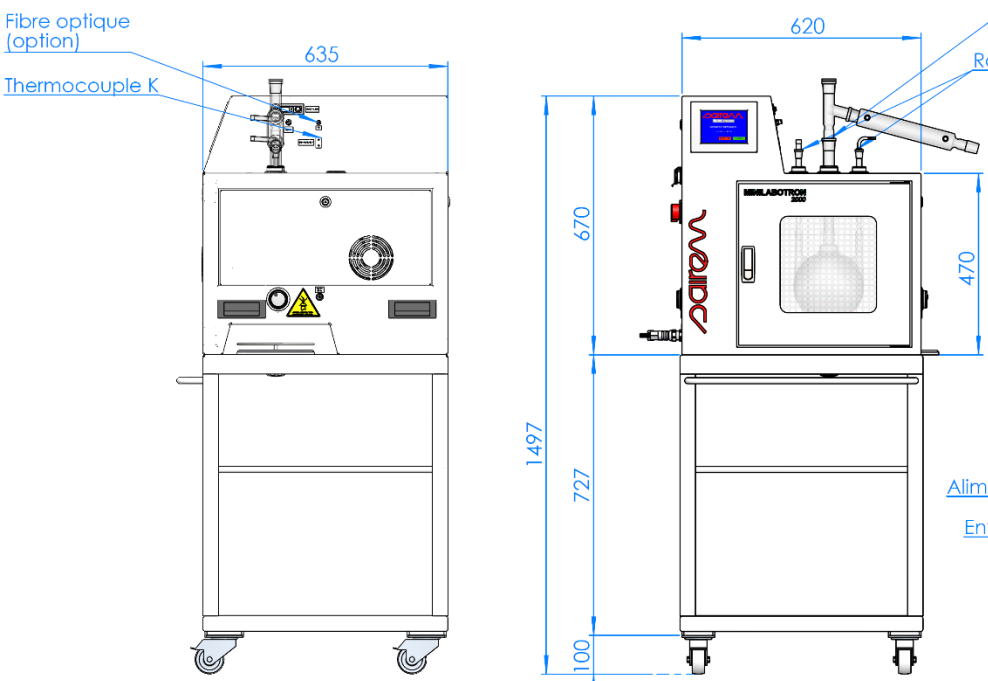

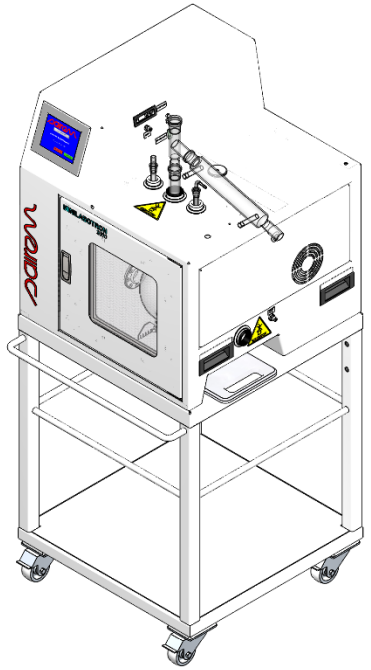

INDICE	DATE	DESSINE	VERIFIE	APPROUVE	MODIFICATION DU DESSIN
C	16/05/13	ML			MIS A JOUR
A	30-04-10	BDE			EMISSION ORIGINALE

12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com

FORMAT: A3

ECHELLE : 1:12

WEIGHT: 129.10

TITRE:
MINILABOTRON 2000

DESSIN NO.
3289-ENS C

12 porte du Grand Lyon, 01702 Neyron Cedex, France, www.sairem.com
☎ : +33 4 72 01 81 60, 🖷 : +33 4 72 01 81 79 E-mail : commercial@sairem.com

LABOTRON EXTRACTION & SYNTHESIS 2450 MHz

The LABOTRON™ series is the generic name for a ground breaking range of integrated reactor and microwave transmission systems especially designed to carry out microwave-assisted processes in batch or in continuous flow. The LABOTRON implements SAIREM's patented INTLI (internal transmission line) technology together with the U-waveguide, WO 2009/122101 and WO 2009/122102.

Fig. 1. LABOTRON™ 6 kW with batch reactor

Fig. 2. LABOTRON™ 2 kW with CF reactor

The LABOTRON™ provides enhanced safety, assured process compatibility, minimum footprint and reduced cost of ownership compared to the more conventional approach of microwave-assisted systems. A centralized control strategy allows for energy conservation. Other benefits include lower installation costs and shorter installation time.

The principle of the microwave-assisted processing using INTLI is to bring, very selectively, a great quantity of energy **directly** inside the reaction mixture. The LABOTRON can cover a wide area of chemical processes enabling efficient and reproducible syntheses from a few grams/hour to more than 1 kg/hour. The INTLI technology brings new prospects to the microwave chemistry and in particular, to the possibility of scaling-up processes in continuous flow.

The LABOTRON improves considerably the performance of microwave-assisted chemistry due to:

- Optimized geometry of the INTLI to achieve high power densities inside the reactor, up to several kW/L;
- Microwave energy can be selectively concentrated inside the reaction by using a solvent relatively transparent to microwaves;
- The external cooling via a metallic jacket can maintain the reagents and their products at very low temperatures to avoid the degradation of the delicate molecules;

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- Continuous flow or batch mode process;
- Direct reading of forward and reflected power values to enable the correct calculation of the energy absorbed by the irradiated sample.

Other advantages are:

- Automatic impedance tuning for minimal levels of reflected power and maximum efficiency of the microwave-assisted process;
- Quick-connections for increased flexibility and rapid cleaning & maintenance;
- Possibility of quick-adapting several types of reactors – standard or custom made - on the **same** microwave head;
- Possibility of scaling-up at 915 MHz if the required microwave power is higher than 6 kW;
- Batch reactor: efficient mechanical stirring with adjustable speed;
- PLC-based controller and touch screen user interface; all system functions and status, including recipe changes, alarms and chemical levels are accessible from the touch screen display;
- On-line reagents addition and products removal & sampling;
- Based on a mobile platform for quick installation and positioning.

OPTIONS

The LABOTRON is supplied with a choice of two microwave generators, i.e. 6 kW (Fig. 1) and 2 kW (Fig. 2) and a choice of microwave-assisted reactors, which include batch reactors and continuous flow reactors. The exact choice of technology is driven by the process type, the process recipe and customer requirements pertaining to utility availability, cost of ownership and chemical performance.

1. **LABOTRON X** – system designed to carry out microwave-assisted extraction from laboratory scale up to industrial scale;
2. **LABOTRON S** – system designed to perform microwave-assisted synthesis from laboratory scale up to industrial scale.

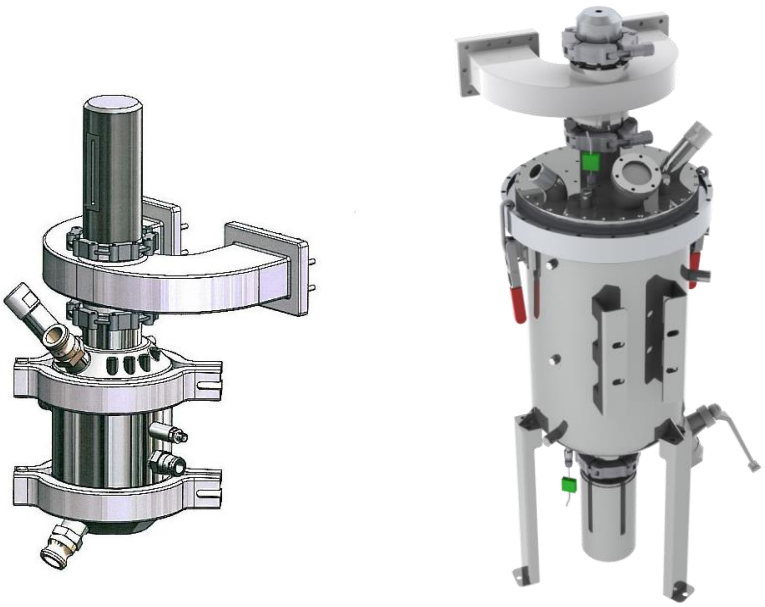
Two types of reactors are available with the LABOTRON:

- ***Batch reactor*** with volumes from 1.5 L up to 20 L (Fig. 3a) within which the INTLI is placed in the middle of the reactor in direct contact with the reaction mixture. The reactor is made out of high quality stainless steel and features an external cooling jacket and internal stirring system by mechanical stirrer. The reactor & INTLI can be fully lined with PTFE or Hastelloy to ensure that any solvents and acids can be safely employed. Other features of the batch reactor include: ¼ inch Swagelock fitting and mass flow meter for gas (nitrogen, air etc.) usage, connection for a condensation/distillation column, up to 4 thermometers (optical fibre or thermocouple), port for reagent addition as the reaction proceeds (without the need of turning the microwaves off), for on-line sampling etc. The cooling of the reactor can be controlled and programmed as such that cooling will be ON only if necessary; the control of this function is driven by the reaction temperature;
- ***Continuous flow*** **(CF)** reactor features SAIREM's innovative SPIN reactor (Fig. 3b) proven to improve yield, selectivity and safety of liquid-liquid and liquid-vapour reactions. Temperature measurement and control is available via a thermocouple installed at the exit of the reactor.

The LABOTRON™ has a very degree of versatility: all reactors are easily interchangeable and the connections are made via standard quick-release connectors. The same system can be easily configured to perform numerous applications including solvent extraction, chemical synthesis, hydrolysis etc. at laboratory scale and industrial scale.

The LABOTRON™ contains built-in proprietary software safeguards (**R**eactor **A**ctive **R**ecognition **C**ontrol) that disallow programming to unsafe combination of power and reactor type. The RARC software is easy to use, self intuitive with control style which can be selected for any method or reactor from ramp to temperature and ramp to microwave power, set-point control, multiple ramps, time, recipe choice & storage etc.

The LABOTRON™ has numerous standard safety features and interlocks that automatically monitor and control the operation to ensure safe and reliable functionality at all times: continuous microwave power control, pressure and temperature sensors, load sensing, microwave leak detection.



20 L

1.5 L

Fig. 3a. Batch reactors mounted on the U-shaped waveguide

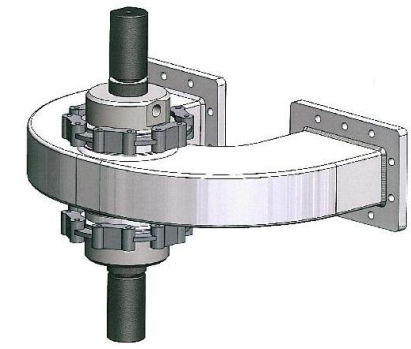


Fig. 3b. SPIN (continuous flow) reactors mounted on the U-shaped waveguide

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MAIN TECHNICAL PARAMETERS

REF.		LABOTRON X or LABOTRON S
Microwave frequency		2450 MHz
Maximum microwave power		2 kW continuous wave (CW) or pulsed, adjustable from 0 W to 2000 W
		6 kW continuous wave (CW) or pulsed, adjustable from 600 W to 6000 W
Microwave tuning		Auto-tuner
Control		- Forward power, reflected power and temperature via integral PLC/digital display - Touch screen: coloured 12 inch display, protected again chemical splashes - Data registration: data logging ports RJ45 and USB
Safety		- Reactor Active Recognition Control - Pressure release valve at 1.5 bar - Inside cabinet pressure switch - Isolator for magnetron protection from reflected energy and to assure constant power output - Retractable drip tray to contain any accidental fluid leaks, splashes etc. - Anti-splash display protection - Cabinet painted in anticorrosive paint - Visible (red, yellow, green) signal tower and sounder - Hardwired microwave leak detector
Temperature measurement & control		- Optical fibre (from -80 up to 250 ^{0}C) - Thermocouple type K, Inconel, up to 950 ^{0}C
Reactors	Batch	- Volume from 1.5 L to 20 L; to be specified with order; - Material of construction: stainless steel* - Cooling: water - Working pressure: max. 1.1 bar - Stirring: mechanical stirrer with adjustable speed
	SPIN CF	- Volume 40 ml - Material of construction: borosilicate glass (Pyrex)** - Integral pump with adjustable flow - Cooling: silicone oil (oil bath not supplied)
INTLI		Aluminium or anticorrosion protected aluminium
Power requirements – supply		**2 kW system:** 1-phase 240 V 50/60 Hz; 3 x 208 V 50/60 Hz
		6 kW system: 3-phase 400 V, 208 V, 50/60 Hz
Microwave generator cooling		**2 kW system:** Water, min. 4 L/min **6 kW system:** Water, min. 10 L/min
		With integrated electrovalve for control. T_{water} = 18 – 25 ^{0}C, $T_{ambient}$ = max. 40 ^{0}C
Dimensions (H x L x W) mm Each side panel requires 650 mm when fully opened		**2 kW system**: 1560 x 661 x 1100 (with U-waveguide and reactor mounted)
		6 kW system: 1600 x 900 x 1100 (with U-waveguide and reactor mounted)

* Other metals could be also ordered, e.g. hastelloy. Inconel etc.

** Fused silica (Quartz) on request

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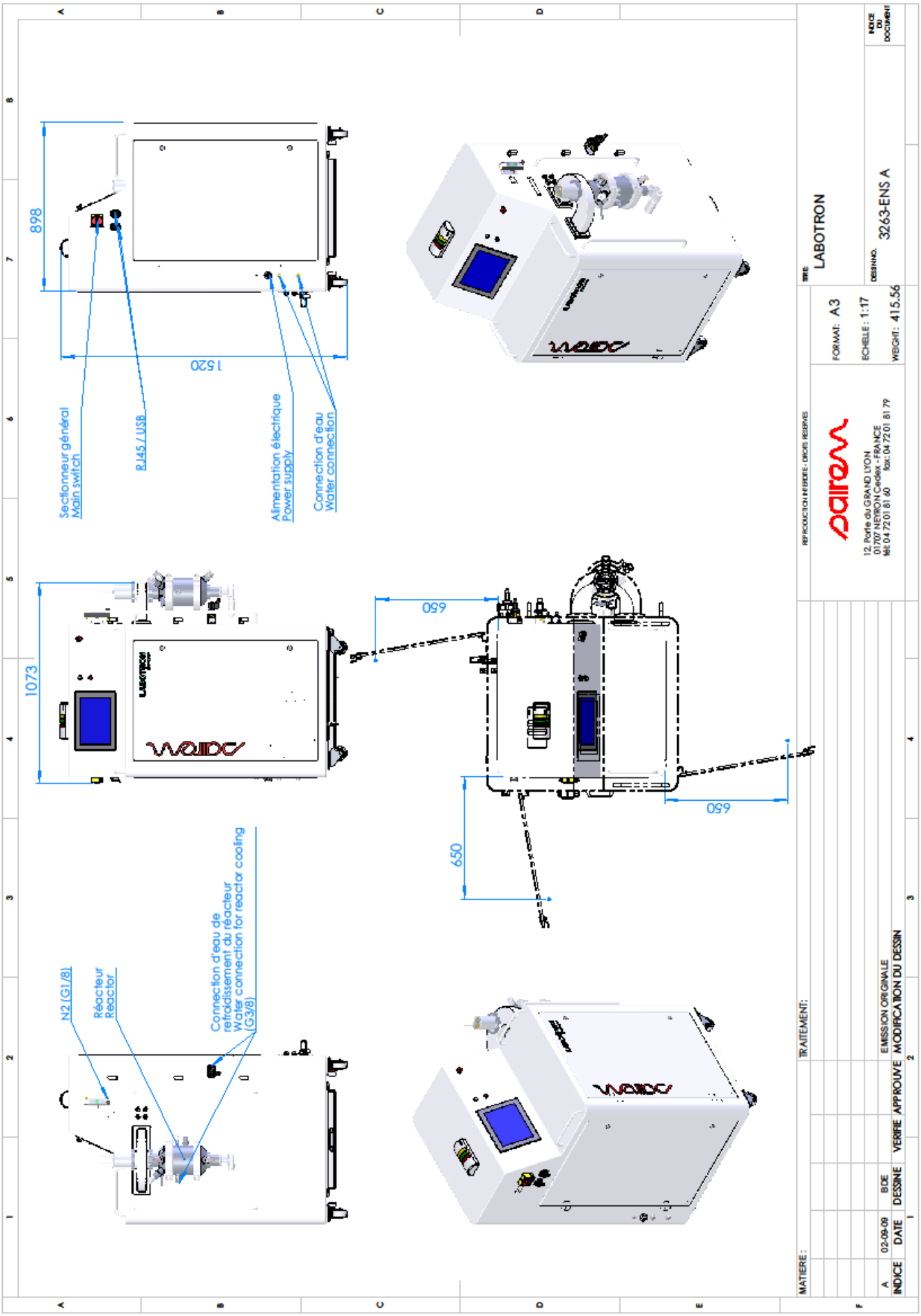

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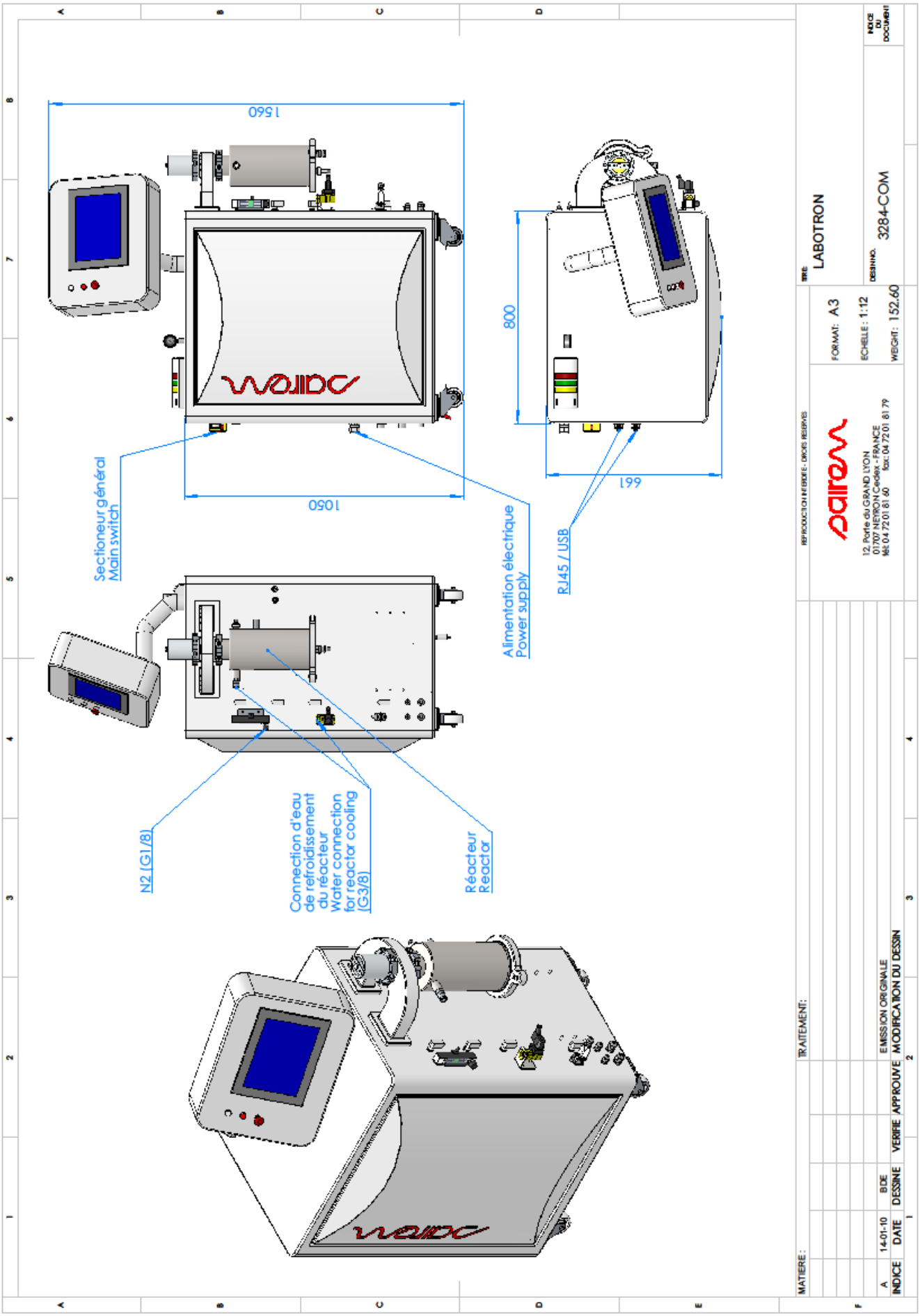

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HIGH TEMPERATURE MICROWAVE FURNACE LABOTRON™ HTE M30K B or M60K B

The Labotron™ HTE M60K B or M30K B is a microwave-assisted high performance furnace designed for elevated temperature processing (e.g. sintering) and can be used both for laboratory & industrial applications.
LABOTRON's high performance is assured by the choice of aluminium as wall-material (reminder: aluminium has over 10 times higher electric conductivity than stainless steel) and by the integrated impedance tuner, i.e. E/H tuner with magic-T. Due to this, the LABOTRON HTE M60K B or M30K B can equally treat high microwave absorbing materials as well as very low absorbing ones, ex. ceramics, glass etc. The homogeneity of the treatment is guaranteed by two main construction features:
- 'Mirror polishing' finish of the internal walls allowing for the irradiated heat by the sample to return to the sample itself thus, increasing the efficiency of the heating process (90% IR reflexion);
- Turning table with alternate rotation.

In addition, the integrated microwave generator allows microwave treatment in continuous wave (CW) or in controlled pulsed regime.
The Labotron HTE can be used for the treatment of high volume samples, significant for scaling-up. Equally, when used adequately, the system allows for very fast rate of heating.

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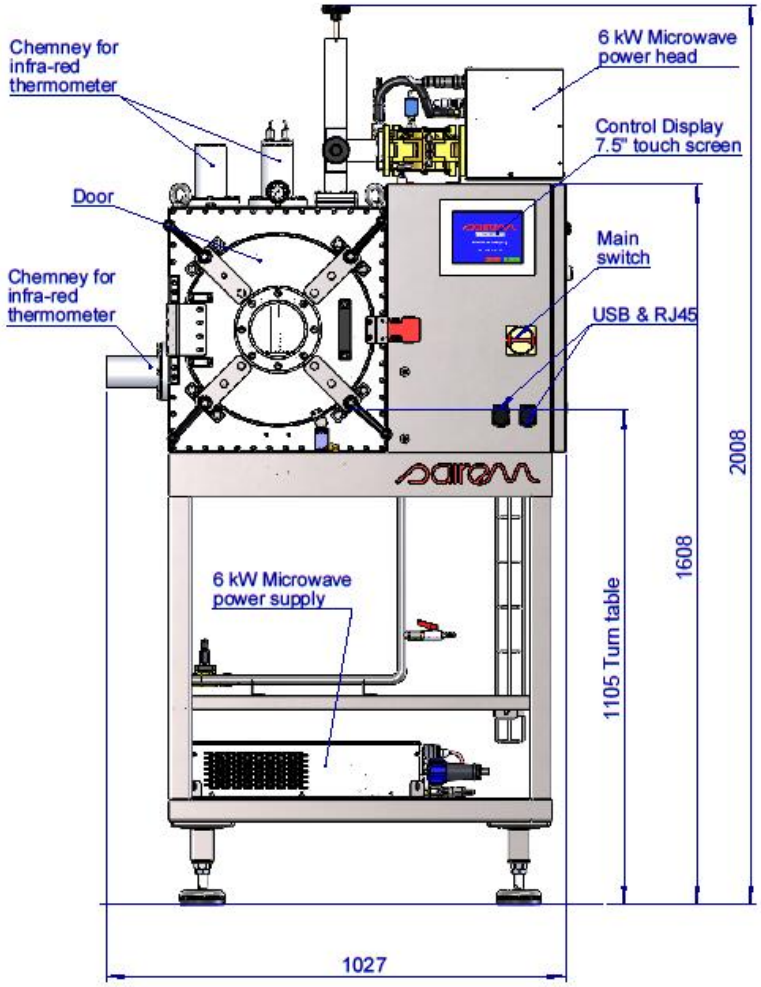
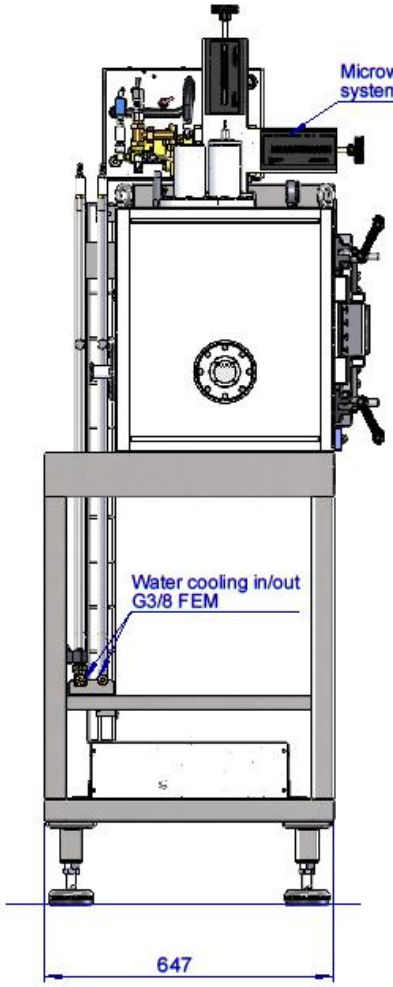
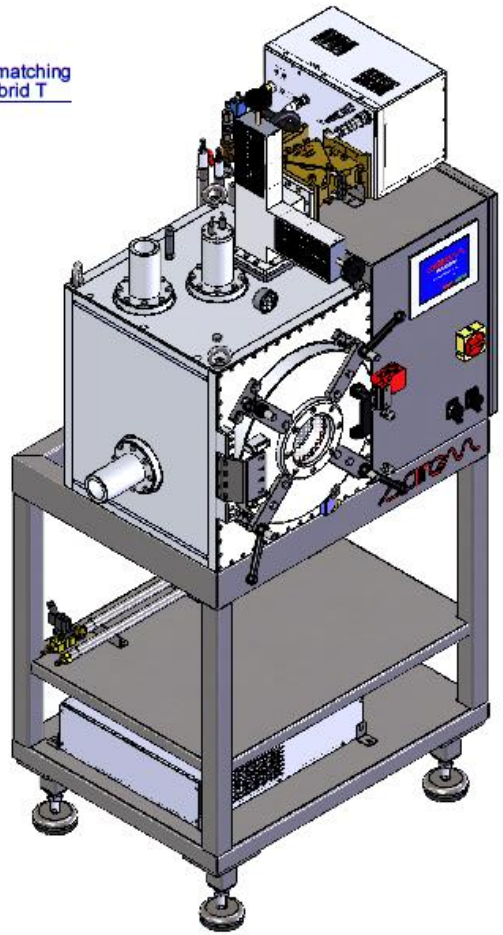
REF.	**LABOTRONHTEM60KB with max. 6 kW microwave** **LABOTRONHTEM30KB with max. 3 kW microwave**
HMI Control	Coloured touch screen digital display 7.5'' Data loading in csv files, USB, RJ45 Programming: power, temperature, time, microwave pulse, incident & reflected power etc.
Microwave cavity	Aluminium, internal size 427x427x488 mm (V = 88 L), 30 mm thick walls, inside-wall mirror polishing, turn table, hand-operated door
Temperature measurement/control	Standard: from oven's top central port via 2 infrared thermometers: 1st from 50 to 400 ^{0}C, 2nd from 400 to 1700 ^{0}C, regulation and steps temperature control. When microwaves are applied, the product to be heated increases its temperature depending on its thermal properties (Cp)
Heating rate	For 6 kW microwave power transferred in to product, the heating rate is 30 ^{0}C/s for 1 kg sample, with average Cp = 2 $Jg^{-1}K^{-1}$ (before heat loss overcomes the heating rate). P=m*CP*Δ/t
Vacuum/Pressure treatment	Integrated DN25 flange for primary vacuum (vacuum pump not supplied). Maximum dif. pressure: 0.5 bar (safety release valve)
Microwave generator (switch mode power supply, magnetron head and isolator)	2450 MHz, adjustable power from 600 to 6000 W or from 0 to 3000 W, continuous wave & pulsed operation. Low-ripple reducing the risks of arcing/plasma inside the oven when operating at high electric field, low pressure and high temperature
Windows/Door	Quartz, microwave sealed on the front door.
Turn table	Diameter 330 mm, thickness 2 mm, continue or alternative rotation Material of construction Micalite
Gas inlets/outlets	Standard: 5 gas connections 3/8 G (1 off on the bottom side, 1 off at the rear, 1 off on the left panel, 2 off on the upper panel), manometer from 30 mm Hg vac to 150 psi, safety release valve (1.8 bar)
Impedance matching	Manual E/H impedance tuner & magic T reducing the reflected power level even in case of high power density (small load inside the cavity). Field density measurement
Safety	Safety interlock connected to the microwave generator to avoid running the oven with the door open. On-screen sample temperature warning when furnace's door opens (to avoid wrong manipulation when sample temperature > 60 0C)
Mains	3 x 400 V + earth, 11 kVA
Microwave generator cooling	By water, min. flow 6 L/min, min. 3 bar. Quick release connectors mounted on water inlet and outlet
Sample thermal insulation (option)	Two models of insulation 'cage' can be ordered, 1 L and 8 L; the cage consists of six independent solid walls arranged over the sample like Lego, no screws or other fixing required. The insulating material is made out of pressed silica fibre (max temperature 1600 °C, IR reflexion > 90% between 300 et 2500 µm). An upper aperture (diam. ~ 50 mm) will allow temperature measurement via the 2 IR thermometers. Inside cage dimensions: 1 L model 100 x 100 x 100 mm, 8 L model 200 x 200 x 200 mm, or other sizes on request.
Dimensions, weight	For accurate dimensions see attached drawings, 260 kg (with support)
OBSERVATION	Min. sample diam. 30 mm, max. processing T = 1800 ^{0}C







INDICE	DATE	DESSINE	VERIFIE	APPROUVE	MODIFICATION DU DESSIN
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12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com

FORMAT: A3

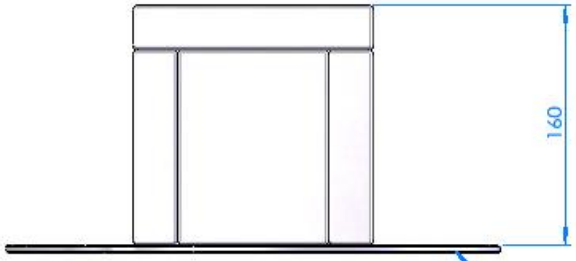
ECHELLE : 1:10

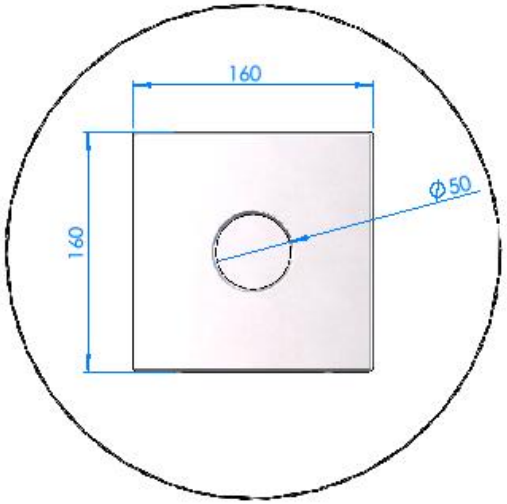
WEIGHT: 301.41

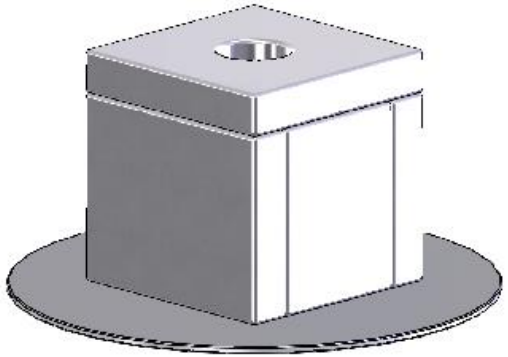
TITRE:
HEIGH TEMPERATURE MICROWAVE OVEN
LABOTRONHTEM60KBVAC

DESSIN NO.
3336-COM

12 porte du Grand Lyon, 01700 Neyron, France, www.sairem.com
☎ : +33 (0)4 72 01 81 60 E-mail : commercial@sairem.com







Plateau rotatif du four
Oven turn table

Plaques d'épaisseur/Wall Thickness: 30mm

Volume interne/Internal volume : (100x100x100) 1L

INDICE	DATE	DESSINE	VERIFIE	APPROUVE	MODIFICATION DU DESSIN
A	28-10-10	BDE			EMISSION ORIGINALE

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12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com

FORMAT: A3

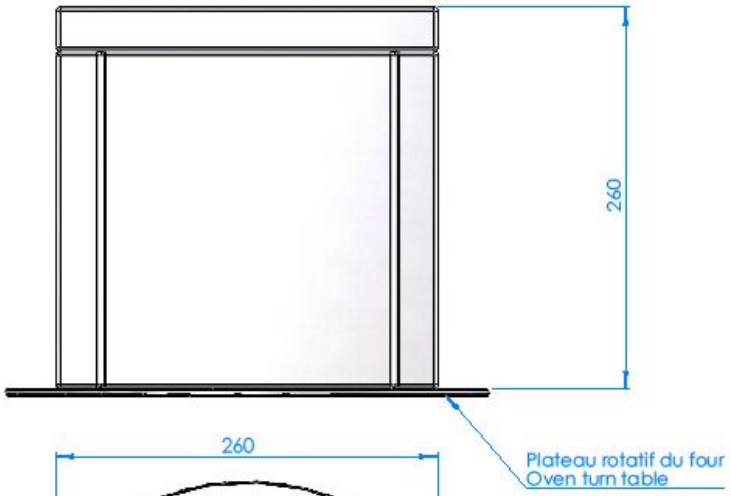
ECHELLE : 1:3

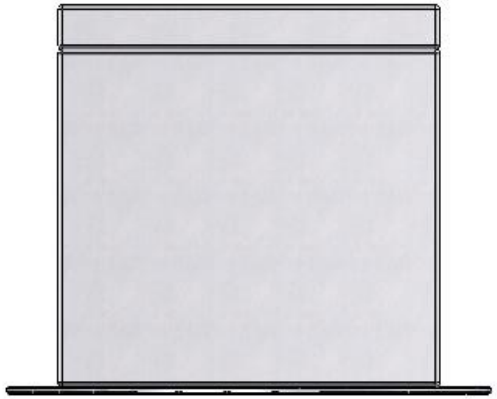
WEIGHT: 7.08

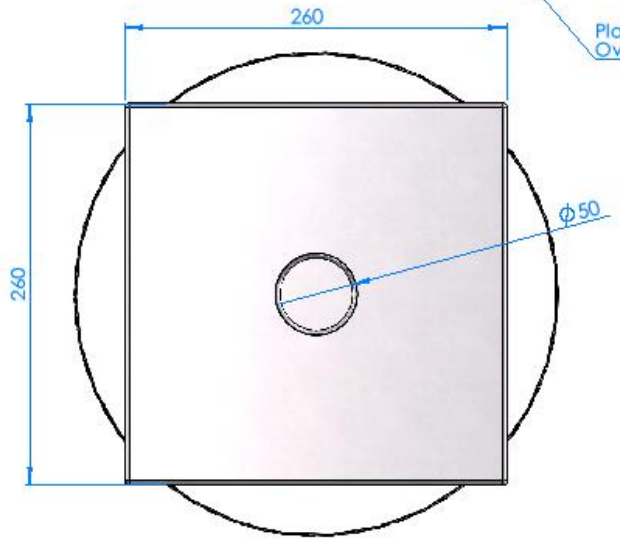
TITRE:
CAISSON ISOLANT
INSULATING CAVITY

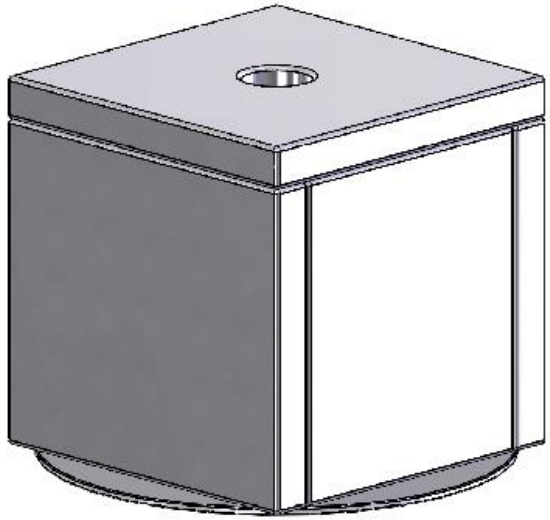
DESSIN NO.
3225-100A

12 porte du Grand Lyon, 01700 Neyron, France, www.sairem.com
☎ : +33 (0)4 72 01 81 60 E-mail : commercial@sairem.com









Plaques d'épaisseur/Wall Thickness: 30mm

Volume interne/Internal volume : (200x200x200) 8L

INDICE	DATE	DESSINE	VERIFIE	APPROUVE	MODIFICATION DU DESSIN
A	28-10-10	BDE			EMISSION ORIGINALE

12, Porte du GRAND LYON
01707 NEYRON Cedex - FRANCE
tél: 04 72 01 81 60 fax: 04 72 01 81 79
www.sairem.com

FORMAT: A3

ECHELLE : 1:3

WEIGHT: 21.31

TITRE:
CAISSON ISOLANT
INSULATING CAVITY

DESSIN NO.
3225-110A

12 porte du Grand Lyon, 01700 Neyron, France, www.sairem.com
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