EPFL
CNQLT 120530/645

JETFIRST 200

INSTRUCTION MANUAL

Revision 5.0

QUALIFLOW THERM S.A.S
Le Millénaire
395, rue Louis Lépine – B.P. 7
34935 MONTPELLIER - CEDEX 9
France
Ph#: +33 (0)4 67 99 47 47
Fax#: +33 (0)4 67 99 47 48

In order to contact your local representative,
please visit our web site at www.jipelec.com

Identification					
Reference	**D 10-098**	Revision	**V50**	Date	10 / 06 / 2009
Document name		JETFIRST 200 - User Manual			
File name		Jetfirst200_special_en_v50.docx			

Control					
Author		Verified		Approved	
Visa	Date	Visa	Date	Visa	Date
Gilles Sanchez	June, 2009	Didier Stupfler	June, 2009	René-Pierre Ducret	June, 2009

History				
Author	Date	Description	Revision	Status
Gilles Sanchez	Sept, 2007	**Creation of document**	V00	Complete
Gilles Sanchez	June, 2009	**Major update, based on version V20**	V30	Complete
Gilles Sanchez	March, 2012	**Minor update – JetFirst V4**	V41	Complete
Gilles Sanchez	July, 2012	**Update**	V50	Complete

CONSTRUCTOR'S FOREWORD

The Jipelec system can be used in R&D. It is obvious that all gases have not been tested and that, consequently, the user must take all the necessary precautions to prevent certain mixtures occurring.

The constructor declines all responsibility for any incidents caused by insufficient precautions or handling errors, and their consequences.

The constructor specifies that the Jipelec system has no protection against any possible toxic emanations.

The responsibility for installing the machine in an environment which complies with the relating legislation is left entirely to the initiative and charge of the user, who is considered to be aware of the effects of the gases that he uses, as well as those of the decomposition products and gases generated by the processes in operation.

The user shall be responsible for connecting the exhaust line and the pump exhausts of the system to a gas scrubbing installation which is compatible with the process gases and gas flows and that complies with local regulation.

The constructor also specifies that the quartz tube and all parts in contact with vacuum or process gases must only be handled with gloves to avoid any pollution.

All maintenance and servicing work should be carried out by skilled personnel and, where specified, in relation with QUALIFLOW THERM Service Department.

QUALIFLOW THERM Service Department and Process Department will provide additional information or recommendation upon request.

TABLE OF CONTENTS

CHAPTER 1. GENERAL INFORMATION......1

1.1. WELCOME 1

1.2. MANUFACTURER WARRANTY...... 1

1.2.1. Warranty conditions 1

1.2.2. Liability and Warranty 1

1.3. SAFETY INSTRUCTIONS 2

1.3.1. User's manual pictogram definitions......2

1.3.2. Personnel qualifications 2

1.4. STANDARDS...... 2

CHAPTER 2. SYSTEM OVERVIEW 3

2.1. GENERAL OVERVIEW 3

2.2. SPECIFICATIONS...... 4

2.3. FEATURES 5

CHAPTER 3. SYSTEM DESCRIPTION 6

3.1. FURNACE 6

3.2. REACTOR 6

3.3. GAS CIRCUIT 9

3.4. VACUUM CIRCUIT...... 10

3.4.1. Description......10

3.4.2. Standard Vacuum and gas diagram 11

3.4.3. Pressure controller (optional) 12

3.4.4. Turbo pumping unit (optional) 13

3.4.5. Vacuum valves states sequences 14

3.5. WATER CIRCUIT...... 16

3.6. PNEUMATIC CIRCUIT 16

3.7. TEMPERATURE CONTROL...... 16

3.8. COMMANDS 17

3.8.1. PC and Programmable Logical Controller (PLC) 17

3.8.2. Front panel 17

3.8.3. Rear panel 17

3.8.4. Electrics......17

3.9. DIMENSIONS AND FOOTPRINT...... 18

3.10. FACILITIES 18

CHAPTER 4. SYSTEM INSTALLATION 19

4.1. HANDLING AND INSTALLATION SYSTEM 19

4.2. ELECTRICITY...... 19

4.3. COOLING UNIT...... 20

4.4. PNEUMATIC CIRCUIT 20

4.5. WATER...... 20

4.6. VACUUM AND GAS CIRCUIT 21

4.6.1. Standard version......21

4.6.2. Pressure controller version (optional)......21

4.6.3. Turbo pump version (optional) 21

CHAPTER 5. SYSTEM SETTINGS-UP...... 22

5.1. ADJUSTING THE INLET GAS FLOW FOR EACH MFC 22

5.2. ADJUSTING THE RELIEF VALVE...... 22

5.3. ADJUSTING THE PYROMETER EMISSIVITY 23

5.4. INSTALLING THE THERMOCOUPLES 24
5.5. ADJUSTING THE AIR PRESSURE SWITCH 25

CHAPTER 6. SYSTEM START-UP 26

6.1. BEFORE START-UP 26
6.2. START-UP OF THE SYSTEM 26
6.3. RUN A PROCESS 26
6.4. END OF PROCESS 27

CHAPTER 7. SAFETY FEATURES 28

7.1. FAILURES ACTION LIST 28
7.2. EMERGENCY STOP 28

CHAPTER 8. SYSTEM SOFTWARE CONTROL – PIMS 29

8.1. MAIN INTERFACE 29
8.2. COLOR CODE 30
8.3. RECIPE MODE 31
8.3.1. Recipe manager 31
8.3.2. Recipe edition interface 35
8.3.3. Entering parameters 38
8.3.4. Recipe display 43
8.4. PROCESSING MENU 45
8.4.1. Download recipes 46
8.4.2. Process monitoring 47
8.4.3. Save Process 48
8.4.4. End of process 49
8.5. MAINTENANCE MENU 50
8.5.1. Menu 50
8.5.2. Valves control 52
8.5.3. Vacuum synoptic 54
8.5.4. Gases control 56
8.5.5. Manual heating 57
8.5.6. Inputs / Outputs 60
8.6. CONFIGURATION MENU 63
8.6.1. Pyrometer calibration 63
8.6.2. System Configuration 65
8.6.3. Language 68
8.6.4. Change password 68
8.7. HISTORICAL MENU 70
8.7.1. Historical selection 70
8.7.2. Alarms 72
8.8. TEMPERATURE CONTROLLER INTERFACE 73
8.8.1. Overview 73
8.8.2. Accessing the Temperature Controller interface 74
8.8.3. Setting communication (ON or OFF) 75
8.8.4. Setting temperature regulation parameters 77
8.8.5. Calibration & regulation procedure 81

CHAPTER 9. TROUBLESHOOTING 97

9.1. ALARM BEHAVIORS 97
9.2. TROUBLESHOOTING 98
9.2.1. Water failure 98
9.2.2. Air failure 98
9.2.3. Fan failure 98
9.2.4. Furnace overheating 99
9.2.5. Lamp failure 99
9.2.6. Lamp breaker zone failure 99
9.2.7. TC failure 99
9.2.8. Pyrometer failure 99
9.2.9. Temperature control failure 99

9.2.10. *Vacuum valves failure* ... 100
9.2.11. *Primary pump failure (optional)* ... 100
9.2.12. *Turbo pump malfunction failure (optional)* ... 100
9.2.13. *Turbo pump rotation speed failure (optional)* ... 100

CHAPTER 10. TEMPERATURE SENSORS AND CONTROLLERS ... 101

10.1. TEMPERATURE CONTROL ... 101
10.2. CONDITIONS OF USE ... 101
10.3. TEMPERATURE CONTROL OF SUSCEPTORS ... 102
10.3.1. *How to improve temperature control?* ... 102
10.3.2. *How to reduce the overshoot?* ... 103
10.4. OPTICAL PYROMETER ... 103

CHAPTER 11. MAINTENANCE ... 105

11.1. PERIODICITY OF MAINTENANCE OPERATION ... 105
11.1.1. *Reactor* ... 105
11.1.2. *Furnace* ... 105
11.1.3. *Electricity* ... 106
11.1.4. *Gas and vacuum* ... 106
11.1.5. *Water and compressed air* ... 106
11.1.6. *Safety* ... 106
11.2. CHANGING LAMPS ... 107
11.3. CHANGING THE QUARTZ WINDOW ... 108
11.4. CHANGING THE TOP CHAMBER FLANGE ... 110
11.5. CHANGING THE REACTOR ... 113
11.6. CHANGING THE THERMOCOUPLES ... 116
11.7. DISMANTLING PYROMETER ... 117
11.8. CLEANING THE REACTOR ... 118
11.9. CHANGING CONTROLLER BATTERIES ... 118
11.10. CLEANING PROCESS FOR SILICON CARBIDE PRODUCTS (SOURCE POCO) ... 119
11.10.1. *HF Cleaning Process* ... 119
11.10.2. *RCA Cleaning Process* ... 120
11.10.3. *Bake Methods* ... 120

CHAPTER 12. PIMS SOFTWARE INSTALLATION ... 121

CHAPTER 13. GRAPHITE PARTS – INFORMATION ... 122

13.1. INTRODUCTION ... 122
13.2. THE SIC COATED SUSCEPTOR ... 122
13.3. THE SIC COATING ... 123
13.4. PINHOLE FORMATION ... 123
13.5. OVER-ETCHING ... 123
13.6. PREVENTION OF PINHOLES BY THE USER ... 124
13.6.1. *Unpacking* ... 124
13.6.2. *General* ... 124
13.7. TEMPERATURE GRADIENTS ... 124
13.8. CONCLUSION ... 124
13.9. USE OF SUSCEPTORS IN PROCESS ATMOSPHERE ... 124

CHAPTER 14. APPENDIX ... 125

14.1. FIGURE 1 REACTOR OVERVIEW ... 125
14.2. FIGURE 2 FRONT FACE AND REAR UTILITY PANEL ... 125
14.3. FIGURE 3 DIMENSIONS & FOOTPRINT ... 125
14.4. FIGURE 4 GAS CIRCUIT ... 125
14.5. FIGURE 5 STANDARD VACUUM CIRCUIT ... 125
14.6. FIGURE 6 VACUUM CIRCUIT WITH PRESSURE CONTROLLER ... 125

14.7. FIGURE 7 VACUUM CIRCUIT WITH TURBO PUMP 125
14.8. FIGURE 8 WATER CIRCUIT 125
14.9. FIGURE 9 PNEUMATIC CIRCUIT 125
14.10. FIGURE 10 THERMOCOUPLE & PYROMETER LOCATION 125
14.11. FIGURE 11 QUARTZ PINS INSTALLATION 125

CHAPTER 1. GENERAL INFORMATION

1.1. WELCOME

The following manual relates to the Jipelec JetFirst 200 system, revision V4.

Contact manufacturer:

QUALIFLOW THERM	**Tel: +33 (0) 4 67 99 47 47**	**Web site: www.jipelec.com**
395, rue Louis Lépine – BP7	**Fax: +33 (0) 4 67 99 47 48**	**Email: dstupfler@qualiflow.com**
34935 MONTPELLIER Cedex 9		
FRANCE		

1.2. MANUFACTURER WARRANTY

1.2.1. Warranty conditions

The JIPELEC JetFirst 200 systems have been manufactured and tested with the use of selected and reliable equipments.

QUALIFLOW THERM gives a 12 months warranty on the equipment from date of shipment. Consumables are not covered by the warranty (quartz, graphite or SiC coated graphite parts, thermocouples, lamps, cooling fluids …).

The warranty is valid only if the equipment has been used according to QUALIFLOW THERM instructions.

1.2.2. Liability and Warranty

All obligations of QUALIFLOW THERM under this warranty shall cease if the end-user or third parties:

- Disregard the information contained in the manuals provided with JetFirst 200;
- Use the product in a non-conforming manner;
- Make any kind of changes (modifications, alterations, use of other gases than those specified by Qualiflow Therm for this JetFirst machine, …);
- Use the product with accessories, not listed in the corresponding product documentation.

Reasonable care must be used to avoid hazards. QUALIFLOW THERM expressly disclaims responsibility for loss or damage caused by use of its products other than in accordance with proper operating procedures.

1.3. Safety instructions

1.3.1. User's manual pictogram definitions

	Burn hazard while touching hot parts. This label prevents the user from eventual burning hazards.
	Damage hazard to the system. This label prevents the user from eventual hazards that can damage the system.
	Electrical shock hazard. This label prevents the user of eventual electrical hazards.
	Mechanical pinch hazard. This label prevents the user of eventual mechanical hazards.
	Toxic and/or corrosive gases and chemicals. This label warns the user from the danger and lethal risks involved when using toxic or corrosive chemicals.
	Burn hazard while touching hot parts. Some parts may be hot. Wearing thermal gloves is mandatory.

1.3.2. Personnel qualifications

All installing or maintenance operations and procedures described in this manual may only be carried out by persons who have suitable technical training and the necessary experience or who have been instructed by QUALIFLOW THERM Technical Support Department.

1.4. Standards

JetFirst 200 system is CE marked.

The product complies with the following directives.

- EC machinery directive - 2006/42/CE
- EC low voltage directive - 2006/95/CE
- EC electromagnetic compatibility - 2004/108/CE – Class A

Applied harmonized standards:

- EN 292-1 and EN 292-2, Safety of machinery instruments and systems
- EN ISO 13849/1, Safety of machinery instruments and systems
- EN 60204-1, Electrical equipment for machinery used in the industry
- EN 1050, Risk analysis
- EN 1547:2001, Noise test code for industrial thermoprocessing equipment including its ancillary handling equipment

CHAPTER 2. SYSTEM OVERVIEW

2.1. GENERAL OVERVIEW

The JetFirst system is a low cost bench top RTP processor. It is the perfect tool for R&D application from MEMS to SOLAR. The high reliability allows small-scale production up to 5000 wafers per year.

Housed in a bench top frame, the system includes a cold-wall reaction chamber for wafers up to 8" and/or square cells up to 156x156 mm², and a powerful multi-zone infrared lamp furnace.

Lamp array and isolating window are mounted in a rotating top lid, thus allowing full accessibility to the chamber for easy loading/unloading and maintenance operations.

The PIMS software control allows full process monitoring, data acquisition and pyrometer calibration for a large range of substrate.

A thermocouple accurately measures temperature of substrate. Open or closed loop temperature control modes are selectable.

Applications:

- RTA: Annealing for silicon and compound semiconductor wafers
- RTO: Rapid Thermal Oxidation
- RTN: Rapid Thermal Nitridation
- RTD: Rapid Thermal Diffusion from spin-on dopant
- Crystallization
- Contact Alloying
- Solar applications for PV industry
- And more….

2.2. SPECIFICATIONS

Features	JetFirst 200
Number of lamps	24
Number of zones	3, crossed zones
Max. Substrate diameter	8" wafer, 156x156 cell
Purge gas line	Yes
Process gas lines with MFC	1 up to 4
Temperature range	Up to 1300°C
Thermocouple control range	Ambient to 1000°C
Low Temperature Pyrometer control range	150°C to 1000°C
High Temperature Pyrometer control range	400°C to 1300°C
Width (mm)	850
Depth (mm)	750
Height (mm)	675
Weight (Kg)	150
Max. Power	55 kW

2.3. FEATURES

Control panel

See **fig. 2** in appendix for front face representation.

Including:

- ON/OFF push buttons;
- EMERGENCY STOP button.

Electrical part

Including:

- SCR Power controllers
- Contactors;
- Circuit breaker;
- Transformer;
- Automaton
- Terminals.

Equipment

<u>Upper part</u> includes the following components:

- Furnace and lamps;
- Lamp air cooling cross-flow fans;
- Reaction chamber;
- Quartz window, upper flange.

<u>Lower part</u> includes the following components:

- Platen, quartz pins and thermocouples;
- Optical pyrometer;
- Gas panel;
- Water circuit;
- Vacuum valve and constraint vacuum gauge;
- QF fitting for vacuum pump installation.

See **fig 1** in appendix for main reactor components localization.

Rear Side

See **fig 2** in appendix for rear face representation.

All connections (power supply, water, air, gases and vacuum) are available on rear face.

CHAPTER 3. SYSTEM DESCRIPTION

3.1. FURNACE

See **fig. 1, 2 and 3** in appendix for general overview, dimensions and footprint.

The furnace is located in the upper part of the system. It is installed in a rotating top lid with the upper part of the process chamber. The furnace can rotate on the backside to allow sample loading and full access to the process chamber.

The furnace is equipped with **24 tubular infrared lamps**, divided into three heating zones. They are mounted inside a water-cooled and mirror-polished aluminum reflector.

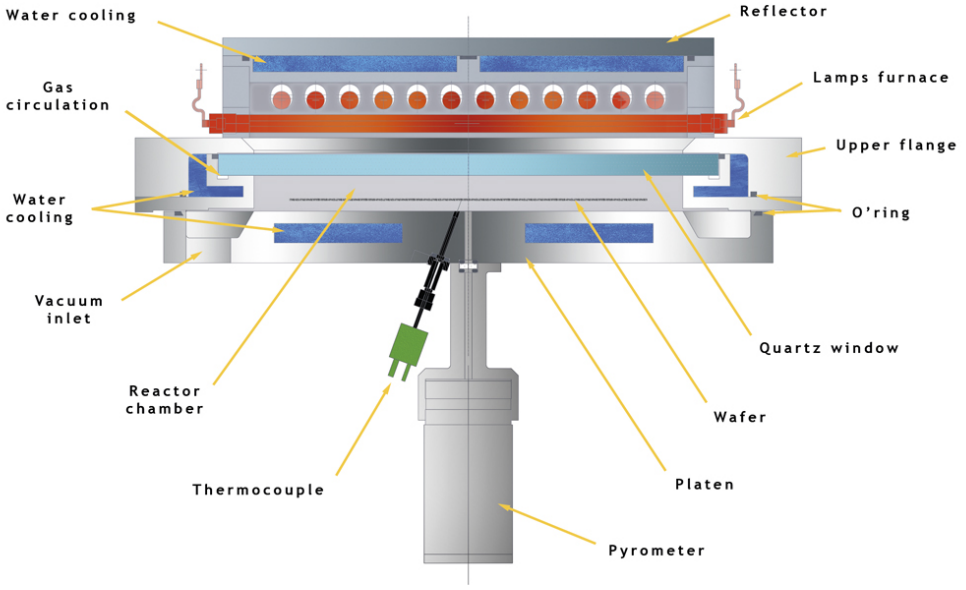
The furnace is fully water-cooled and mirror-polished. Cross-flow fans are used for the **lamps' ventilation** by air. A stainless steel box evacuates the hot air through a rectangular outlet located at the backside of the equipment.

It is possible to lift-up the lamp furnace thanks to a hinge (useful for maintenance operations). For servicing, the furnace is fully accessible once you remove the white metallic box.

3.2. REACTOR

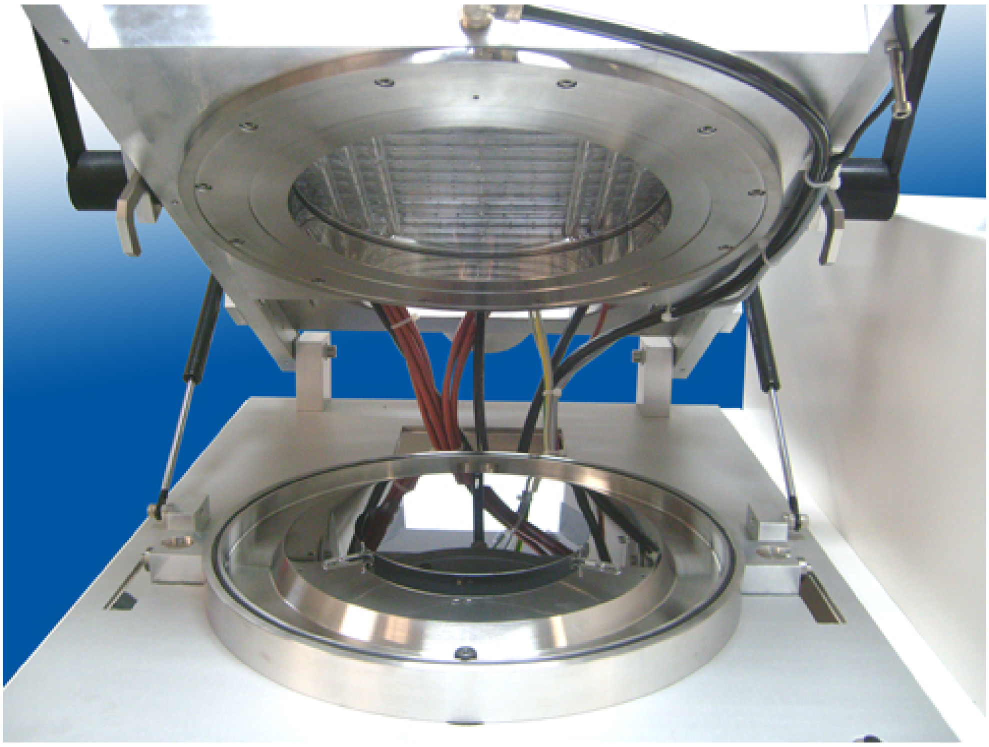
See **fig. 1** in appendix for general overview.

The stainless steel process chamber is a cold-wall chamber with water-cooled and mirror-polished metal walls. An infrared quartz window stanched with Viton O-ring separates the chamber from the furnace.

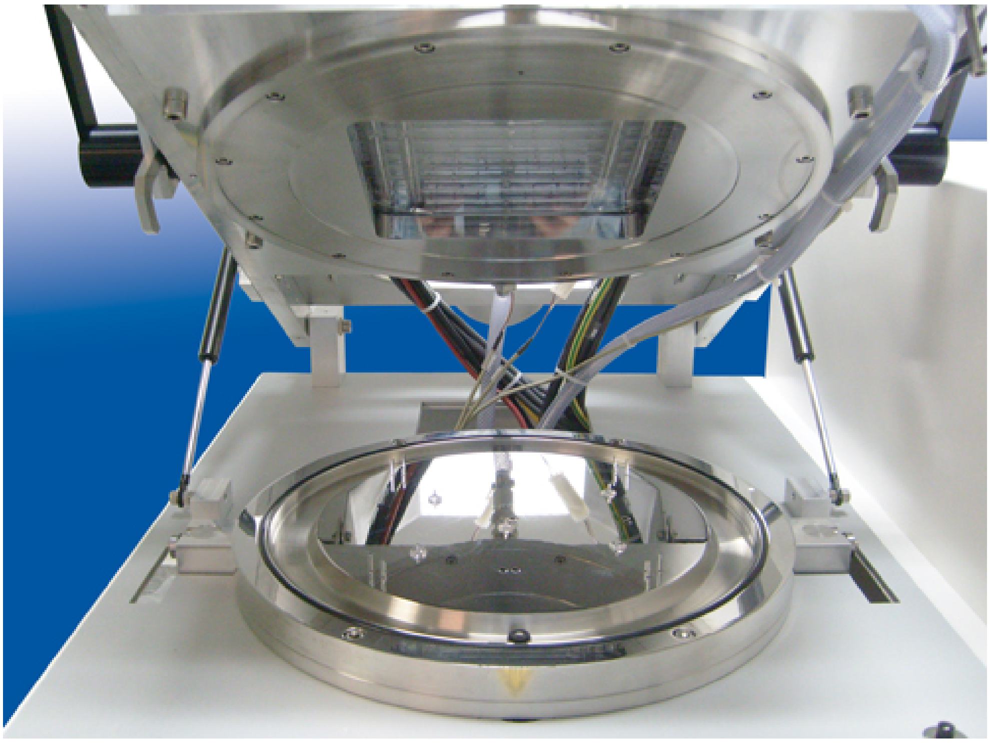


Infrared halogen lamps heat the substrate through a **quartz window** located on the topside of the process chamber.

The reactor opens manually thanks to two gas jacks and is designed for easy loading of the wafer on the platen. **Quartz pins** are installed on the platen to hold the sample. They can be change in a minute to switch to other size of sample.



Reactor for wafer up to Ø200mm

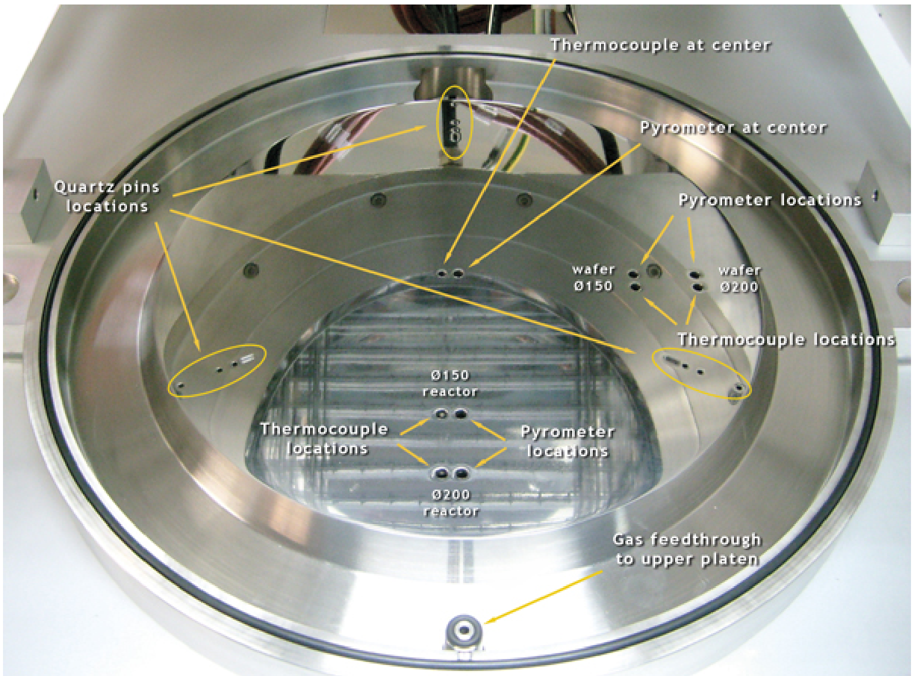


Reactor for solar cells up to 156x156mm

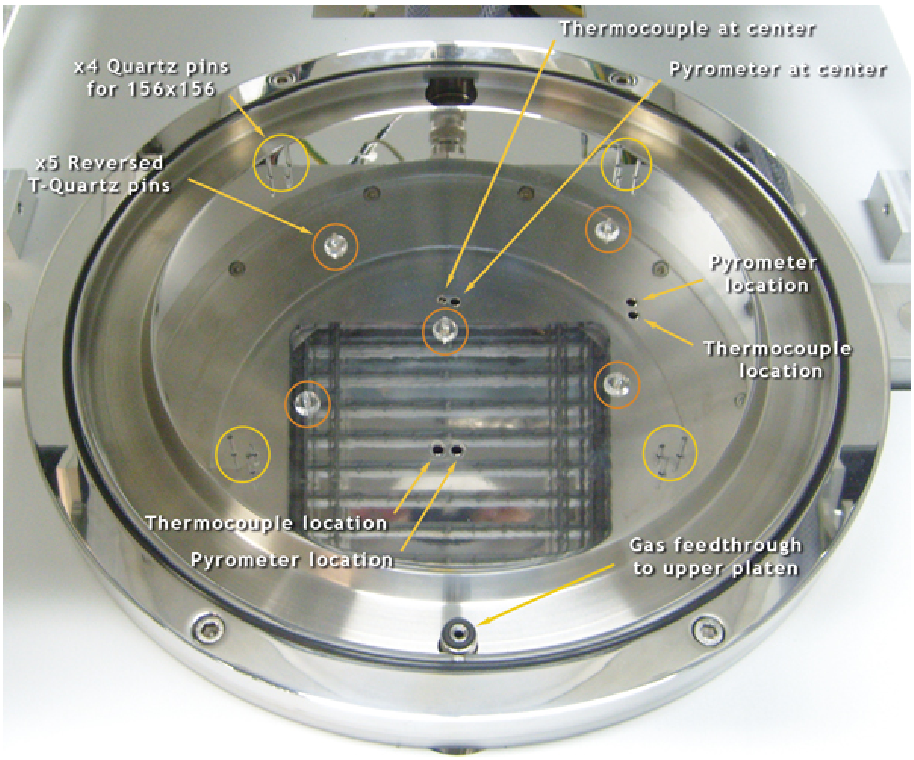
Reactor platen

The reactor platen receives the substrate (wafer or square cell), which is positioned on quartz pins. As an option, a set of quartz pin can be provided for each size of wafer (Ø150 and Ø200) and for square cell of 156x156. For square cells up to 150x150, five reversed T-quartz pins can be provided.

Reactor platen is specific to the type of substrate to process. Reactor design allows to changing platen within a few minutes in order to process wafers or square cells with the same JetFirst system. See reactor changing procedure in **section 11.5**.



Reactor platen for wafer up to Ø200mm



Reactor platen for solar cells up to 156x156mm

On the back of the platen, you fill find fitting elements to install pyrometer and thermocouples at different position as shown on the figures above.

Gas injection

The gas inlet is located under the reactor platen. Gas goes through the reactor platen to the process chamber platen. Gas is injected onto the wafer by 8 holes of the process chamber platen (4 radial and 4 tangential injectors). It circulates around the wafer and the exhaust is done through the vacuum pipe for process under vacuum and through the 3/8' exhaust for pressure at atmospheric perssure.

There is no risk of contamination by the reaction chamber thanks to the **water-cooled walls**.

Temperature control

Up to three thermocouples can be installed under the wafer through O-ring connectors, located under the reactor platen. Thermocouple TC1 is used for regulation, thermocouples TC2 and TC3 are set for reading only.

As a standard, the optical pyrometer looks at the center of the wafer backside. You can move the pyrometer to seven different positions. A second pyrometer can be added to a spare location as shown on the platen representation above.

3.3. GAS CIRCUIT

Standard configuration

The system is provided with a standard purge gas line. Up to **four optional process gas** lines with mass flow controllers can be installed.

Gas is injected in the reactor through a gas valve (GV-N). This valve is controlled by the automaton.

Gas panel is designed with polished stainless steel components and VCR fittings. See **figure 4** in appendix

Purge gas line:

- Manual shut off valve (MV-P);
- 0.22 µm filter;
- Metering valve;
- Pneumatic valve (GV-P).

Process gas line (optional):

- Manual shut off valve (MV-n);
- 0.22 µm filter;
- Digital mass flow controller;
- Pneumatic valve (GV-n).

n = stands for process gas line number

The system can perform both atmospheric and vacuum processes:

- During **vacuum processes**, gases are pumped down through the vacuum valve and the stainless steel hose. A check valve avoids back stream from the gas exhaust line;
- During **atmospheric processes**, gases go out of the chamber by the gas exhaust line.

The **valves** and **mass flow controllers** are fully controlled by the system. Gas flow can be changed at each step of a recipe.

Optional configuration

If equipment is supplied with active gases such as Hydrogen (H_2), the gas circuit is implemented with a ballast gas line with Nitrogen (N_2).

The exhaust gas line allows processes at atmospheric pressure. Vacuum pump is connected to ballast line thanks to a pneumatic valve in order to dilute the by-products exhaust gases, especially while using Hydrogen.

This pneumatic valve is controlled in parallel with the pneumatic gas valve (GV-3). By default, gas line 3 is the dedicated line for active gas.

Ballast line features:

- Stainless steel components 316L;
- 0.22 µm filter;
- Metering valve for Nitrogen flow;
- Pneumatic valve, controlled by GV-3.

3.4. VACUUM CIRCUIT

3.4.1. Description

Standard configuration

The JetFirst system can have vacuum capability thanks to primary and/or secondary pumping units. The chamber tightness is improved by pneumatic valves installed on chamber gas exhaust. The valve on the outlet is normally open and is closed if pressure value is below 900mbar.

The JetFirst system has vacuum capability down to 10^{-2} mbar using optional vacuum pump, and down to 10^{-5} mbar with turbo-pumping unit.

The system is equipped as follows:

- Primary vacuum valve (recipe controlled);
- Pressure sensor (PT);
- Stainless steel flexible hose for vacuum pump and QF16 vacuum fittings;
- 3/8'' Exhaust line.

A 3/8" stainless steel exhaust line allows atmospheric pressure processes and avoids any over pressure inside the chamber. The line is equipped with an exhaust valve EI-V, which is automatically controlled and closes when the chamber pressure <900 mbar.

The outgassing can slightly increase the pressure during the heating. Thanks to the cold wall chamber technology, the walls remain at room temperature during the process and this is a guaranty for a better vacuum level compare to a system with a quartz chamber that will have hot walls and much more outgassing during the process.

See **fig. 4, 5, 6 and 7** in appendix for vacuum and gas circuits.

Vacuum circuit is piloted thanks to pneumatic valves:

- Primary vacuum valve (CV-V);
- Exhaust vacuum valve (EI-V);
- Forepump valve FPV (only with turbo pumping unit);
- Vacuum valve TGV (only with turbo pumping unit).

Optional configurations

The system can be equipped with two different pumping units, primary and secondary vacuum unit. A pressure controller is also available with both vacuum configurations.

Primary vacuum unit:

- Primary vacuum pump (with corrosive oil mist filter and/or alumina trap as options).

Secondary vacuum unit:

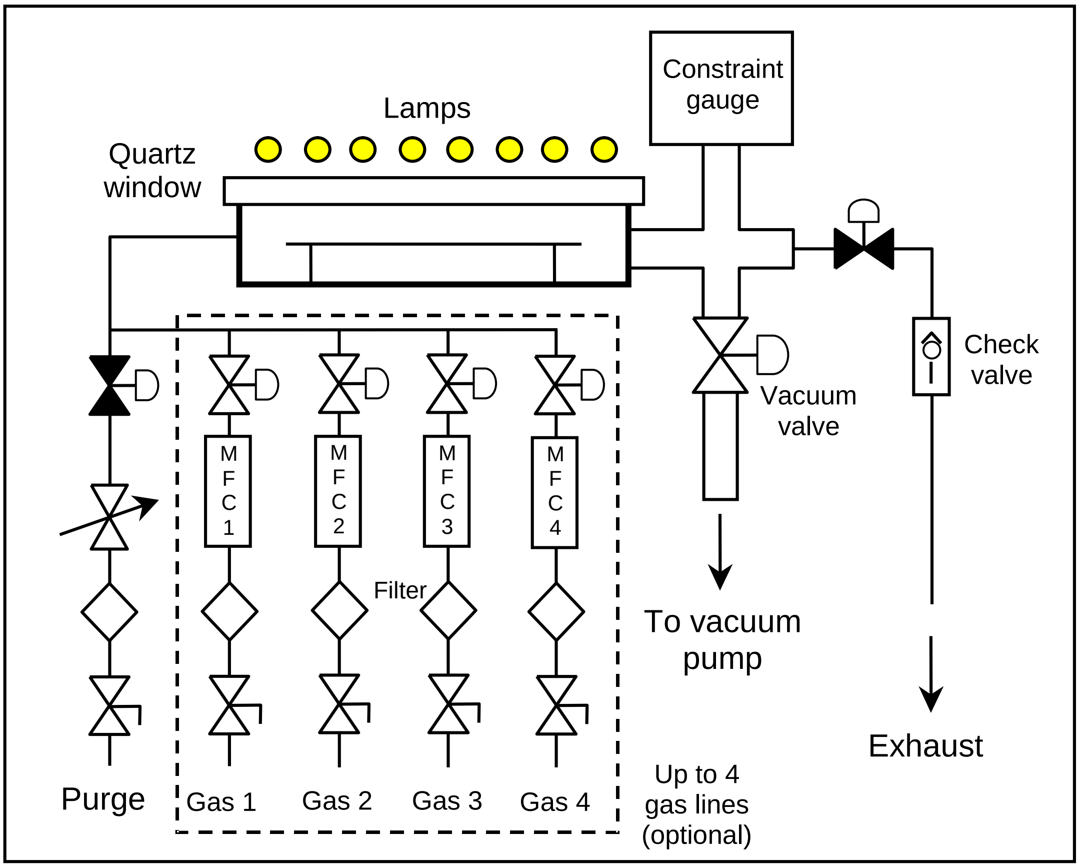
- Primary vacuum pump (with corrosive oil mist filter and/or alumina trap as options);
- Secondary vacuum unit: turbomolecular pump with air cooling kit and controller;
- Forepump valve (FPV);
- Gate valve, recipe controlled (TGV).

Pressure controller unit:

- Capacitance gauge (CAPG);
- Pressure controller box (BVPC);
- Throttle valve (BV).

3.4.2. Standard Vacuum and gas diagram

Here is a schematic of a standard gas and vacuum circuit:



3.4.3. Pressure controller (optional)

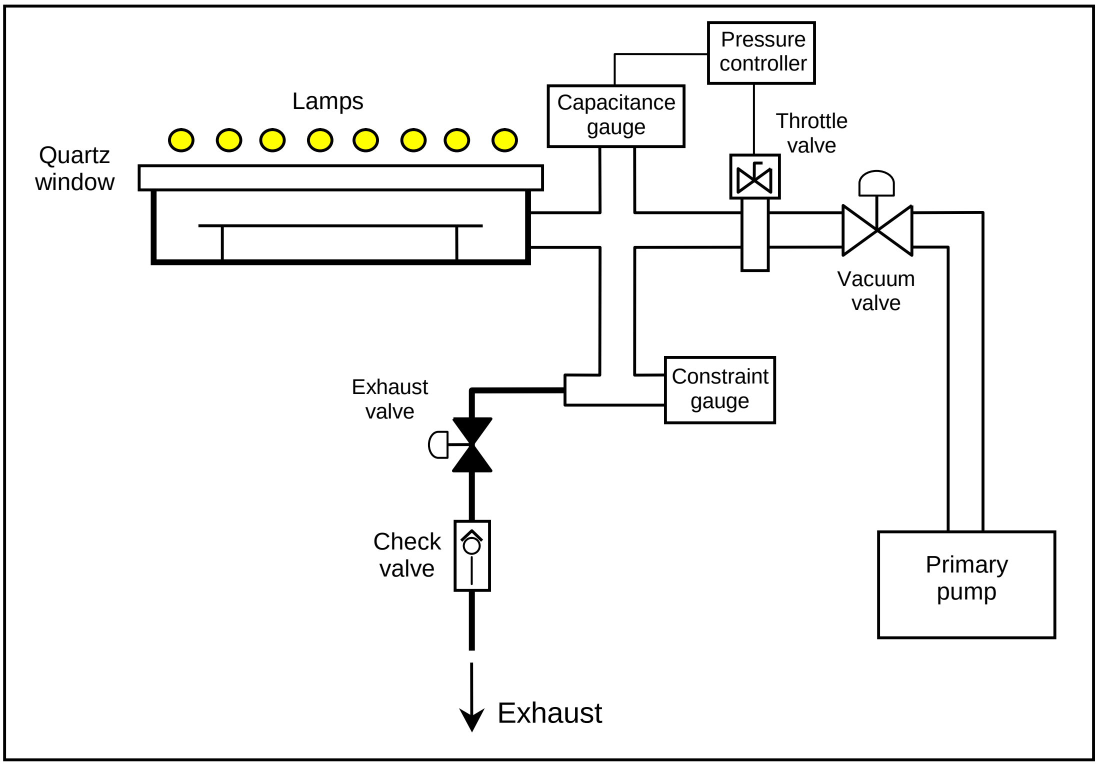
As an option, equipment can be implemented with a pressure controller. Process under vacuum can be run with pressure control for each step of a recipe.

Pressure controller receives signal from the capacitance vacuum gauge and sends information to the throttle valve. Vacuum valve can be commanded through a pressure setpoint or angle setpoint in the process control software.

Features:

- Capacitance gauge (CAPG);
- Pressure controller box (BVPC);
- Throttle valve (BV).

Here is a schematic of the vacuum circuit with pressure regulation:



The PCD receives high level vacuum commands from PIMS. Those commands are :

- No vacuum;
- Primary vacuum;
- Pressure setpoint.

Vacuum system utilizes the following I/O resource:

Inputs

- CVVC : Chamber vacuum valve closed contact;
- PCB : Pump circuit breaker closed contact;
- PT : Chamber pressure sensor;
- BVOP : Throttle valve open.

Outputs

- CVV : Chamber vacuum valve;
- BVAP : Butterfly valve angle / pressure;
- BVO : Butterfly valve open;
- BVC : Butterfly valve closed.

3.4.4. Turbo pumping unit (optional)

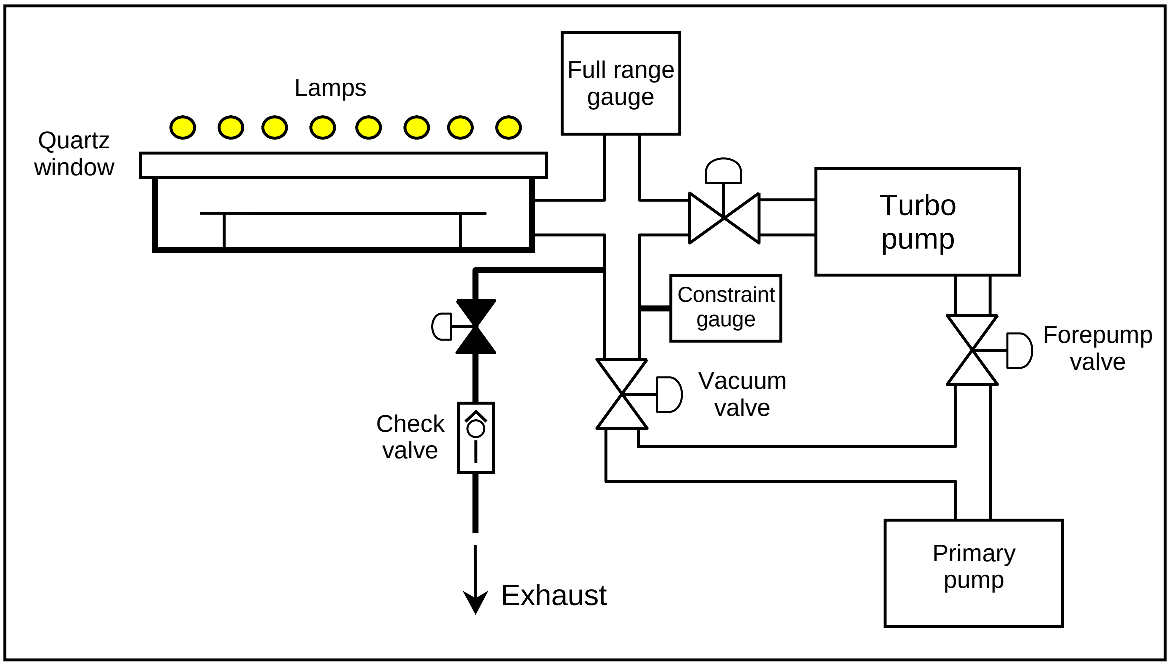
Your equipment can be delivered with a turbo-pumping unit as an option. Vacuum capability can go down to 10^{-5} mbar with this unit.

The turbo pump is specified to be used for cleaning pumping before and during process. The rotary pump is used as a forepump for the turbo pump. This pump can be used to pump oxygen for RTO processes.

WARNING

Turbo pumping cannot be used with active gases and must not be run in process when temperature inside the chamber is over 90°C.

Here is a schematic of the vacuum circuit with a turbo pumping unit.



3.4.5. Vacuum valves states sequences

The vacuum system has been implemented around an FSM (Finite State Machine) in the software. States are explained later in this chapter.

The PCD receives high level vacuum commands from PIMS. Those commands are:

- No vacuum;
- Primary vacuum;
- Secondary vacuum.

Vacuum system utilizes the following I/O resource:

Inputs

- CVVC : Chamber vacuum valve closed contact;
- PCB : Pump circuit breaker closed contact;
- FPVC : Fore pump valve closed contact;
- TGVO : Turbo gate valve Open contact;
- TGVC : Turbo gate valve Closed contact;
- RSA : Rotation speed attained;
- MFO : Malfunction free operation;
- PT : Chamber pressure sensor;
- PKR : High vacuum sensor (For reading only).

Outputs

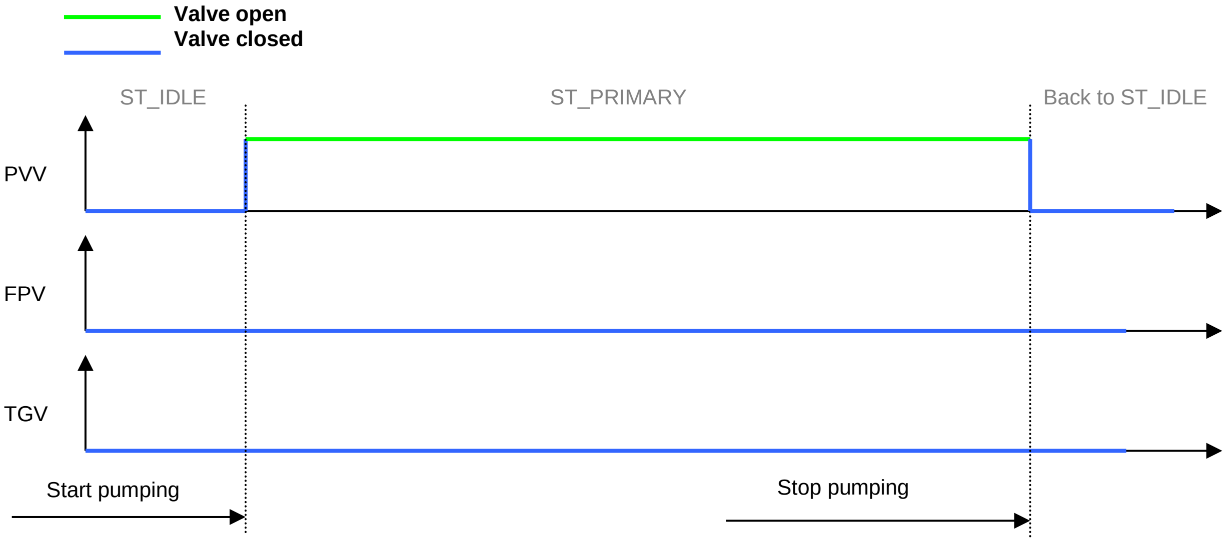
- CVV : Chamber vacuum valve;
- TPSS : Turbo pump start / stop;
- FPV : Fore pump valve;
- TGV : Turbo gate valve.

On every change of either turbo gate valve TGV, forepump valve FPV or chamber vacuum valve CVV, the software checks the actual state after 5 seconds by controlling the corresponding TGVO, TGVC, FPVO, FPVC or CVVC.

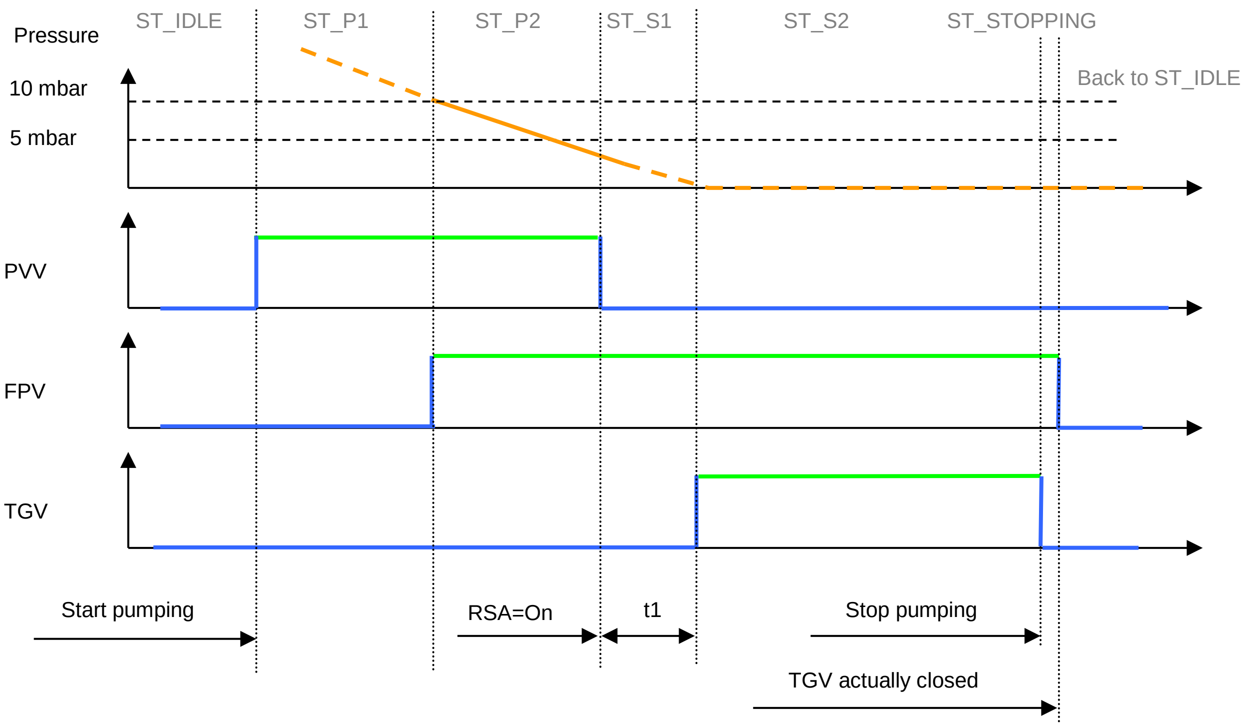
Safeties

- An alarm is raised if the actual state does not match the one we are expecting (see **section CHAPTER 9** for safety features);
- TGV, FPV are closed and TPSS is reset whenever the chamber pressure is over 50 mbar;
- GV_P keeps closed whenever TGV is <u>not</u> closed;
- In order to prevent purge gas from blasting into the turbo pump, GV_P opening is delayed of 5 seconds at the end of a process. This is valid for any ending process reason.

Primary vacuum sequence:



Secondary vacuum sequence:



t_1 : 5 seconds

3.5. WATER CIRCUIT

See **fig. 8** in appendix for water circuit representation.

The JetFirst 200 is equipped with a water cooling circuit. This allows cooling down the main parts of the furnace. The circuit is fully controlled by the automaton.

Parts cooled by the water circuit:

- Reactor chamber;
- Lower and upper flange.

Features of the water circuit:

- Water relief valve;
- Solenoid valve;
- Flowmeter and filter.

> NOTICE
> **The Jipelec JetFirst can be connected to a closed loop water cooling unit, a circulation chiller for example. The cooling capacity of this unit must be at least: 15KW for full cooling efficiency as 50% of the furnace consumption is lost in water.**

3.6. PNEUMATIC CIRCUIT

The pneumatic circuit is only used for valve actuation command of the gas and vacuum circuit.

Pneumatic valves:

- Gas valves GV-1, GV-2, GV-3 and GV-4 (one for each gas line);
- Purge gas valve GV-P;
- Exhaust isolation valve EIV;
- Forepump valve FPV (only with primary pumping unit);
- Vacuum valve TGV (only with turbo-pumping unit).

See **fig. 9** in appendix.

> NOTICE
> **Compressed air must be dry and oil free.**

3.7. TEMPERATURE CONTROL

JetFirst is provided with closed loop temperature control set by thermocouple or optical pyrometer. The system can also be used in power mode (open loop).

- Optical pyrometer: Low temperature or High temperature range;
- Thermocouple: K-type (Chromel/Alumel), ∅0.127 mm;
- Control: PID temperature controller.

3.8. COMMANDS

3.8.1. PC and Programmable Logical Controller (PLC)

The JetFirst is provided with a computer. Full control over the system is done thanks to the Jipelec Process Image Management System (PIMS). It enables creation of recipes, display of parameters and data acquisition during the process. Another module allows pyrometer calibration.

SAIA programmable controller providing detailed control over subsystems, processes and safeties. Another PLC controls the PID temperature regulation.

A plug is available in the electrical cabinet to plug the computer. An optional printer allows paper edition of curves.

3.8.2. Front panel

See **fig. 2** in appendix.

Front panel of the system includes the two main command buttons:

- A ON push-button (green);
- A OFF push-button (red);
- An emergency stop button.

3.8.3. Rear panel

See **fig. 2** in appendix.

Rear panel of the system includes the PIMS cable connector and the external contact connector. The external contact is used for remote control the system power supply, allowing to power supply or not the system.

3.8.4. Electrics

Design:

- A circuit breaker on the rear side protects the furnace;
- Circuit breakers inside the equipment protect the different subsystems;
- A power contactor supplies the furnace during process.

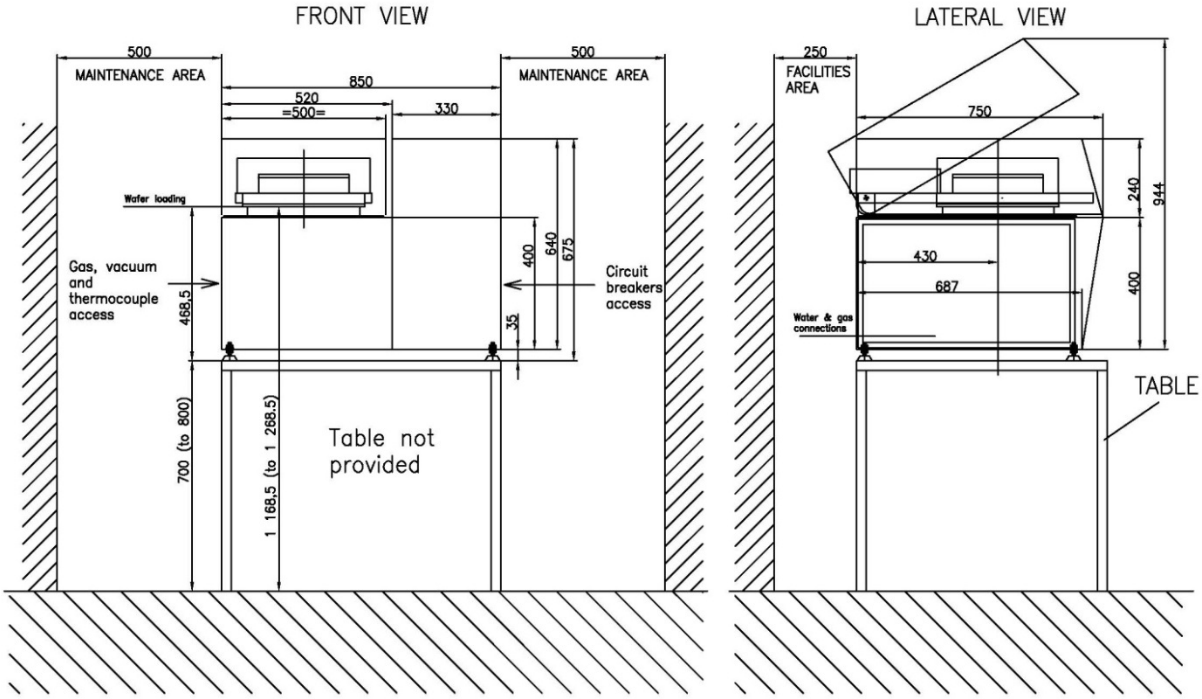
The user must provide a **general circuit breaker** to protect the supply line of the system and the furnace (see installation procedure).

3.9. DIMENSIONS AND FOOTPRINT

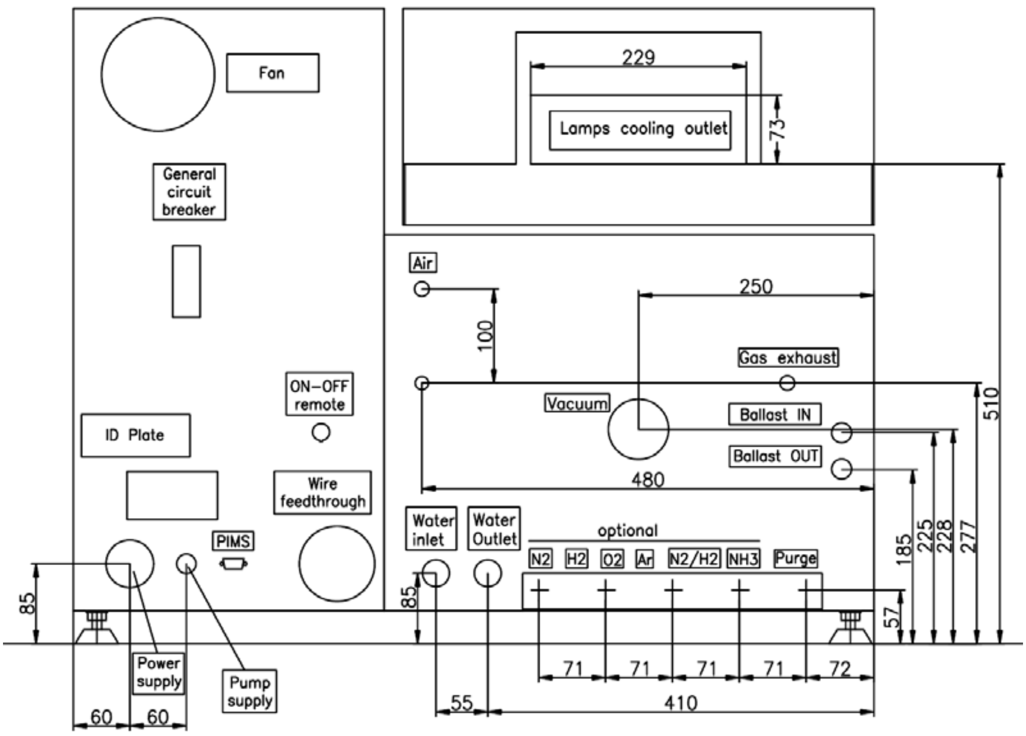
The Jipelec JetFirst system has been designed to get the most appropriate dimensions and footprint in order to facilitate the operator's work and position:

- Dimensions: 850 (L) x 750(W) x 675 (H).

See **Fig. 3** in appendix.



3.10. FACILITIES



CHAPTER 4. SYSTEM INSTALLATION

4.1. HANDLING AND INSTALLATION SYSTEM

IMPORTANT NOTE

The JetFirst system must be installed on a stable flat surface otherwise the frame of the system can be warped and lead to reactor leaks.

The vacuum pump must be installed in ways that avoid vibration of the JetFirst system.

For the handling system, the user must use the help of 3 operators minimum (Weight=150kg) to displace it.

The last step consists in stabilizing the system by making it level. This is very important during process to provide a good and uniform gas injection. Use a standard vertical level and use the threaded feet of the system to make it level.

4.2. ELECTRICITY

Specifications:

System	Voltage	Input voltage	Lamp voltage	Lamp power	Nb of lamps	Max furnace consumption	Total power consumption	Current	Frequency	Breaker range
		V	V	W		W	kW	A	Hz	
JetFirst 200	**3x400V+N+PE**	400	230	1 901	24	45 624	**55**	**80**	50	64-80

The Jipelec JetFirst is provided with a circuit breaker to protect the system.

You will find in the table below, the circuit breaker specifications installed inside the equipment and the power cable preconized.

IMPORTANT NOTICE

The user must use a circuit breaker to protect the mains power cable according to the following table. Power wiring on customer side has to be protected according to these specifications.

System	Voltage	Input voltage	Circuit breaker range	Interrupting capacity	Cable preconised
	V	V	A	K.A	mm²
JetFirst 200	3x400V+N+PE	400	80, curve D	55	5x16 min

4.3. COOLING UNIT

The furnace is fully water-cooled and mirror-polished. Two cross-flow fans are used for the **lamps' ventilation** by air. A stainless steel box evacuates the hot air through a rectangular outlet located at the backside of the equipment. The lamp cooling outlet should be connected to a high temperature hose for hot air extraction.

Features:

- Connect a metallic or plastic exhaust pipe 73 x 229 mm;
- Four cross flow fans 3 x 100 m^3/h + 1 x 330 m^3/h;
- Maximum temperature at outlet 100°C.

NOTICE

The Jipelec JetFirst can be connected to a closed loop water cooling unit, a circulation chiller for example. The cooling capacity of this unit must be at least: 25KW for full cooling efficiency as 50% of the furnace consumption is lost in water.

4.4. PNEUMATIC CIRCUIT

The pneumatic circuit is reserved for valve actuation command.

Features:

- Pressure 6 bars;
- Plastic pipe ∅4/6.

An Ø6 to ¼'' fitting adaptor is provided with the equipment.

See **fig. 9** in appendix.

NOTICE

Compressed air must be dry and oil free.

4.5. WATER

Features:

- Water supply inlet/outlet Rubber pipe, Inner ∅13 mm;
- Inlet / outlet fittings male tailpiece adaptor ½ BSP;
- Water flow 15 l/min;
- Maximum pressure at water inlet 4 bars;
- Max pressure at water outlet 2 bars;
- Minimum inlet temperature 2°C over the dew point;
- Maximum inlet temperature 25°C;
- Maximum outlet temperature 60°C.

See **fig. 8** in appendix.

If you use a chiller, use the above specifications for water supply.

CAUTION

Differential water pressure has to be 2 bars.

A relief valve controls the pressure. This pressure must not exceed 4 bars inside the system and should be controlled each time you start the equipment. Water flow is around 15 l/min.

4.6. VACUUM AND GAS CIRCUIT

4.6.1. Standard version

The equipment is delivered with:

- VCR female fitting as a standard. A VCR Male / Swagelok ¼ adaptor is provided with the equipment;
- Polished stainless steel 316L pipe, ∅6,35mm;
- QF16 vacuum hose, connected under the platen, for pumping;
- Exhaust through a 3/8" Swagelok fitting.

See **fig. 4 and 5** in appendix for vacuum and gas circuit.

4.6.2. Pressure controller version (optional)

If a pressure regulation module is installed, the vacuum hose is different.

Fitting:

- QF 25 vacuum hose to vacuum pump.

Electrics:

The pressure controller is supplied with ±15V. A circuit breaker (Q06) protects the power supply.

See **fig. 6** in appendix for vacuum circuit with pressure controller.

4.6.3. Turbo pump version (optional)

If your equipment is delivered with a turbo pumping unit, here are the main supplies and fittings

The turbo pump is connected to the vacuum circuit through QF fittings:

- QF16 vacuum hose for the forepump valve (FPV);
- QF40 fitting for the turbo gate valve (TGV).

Electrics:

The turbo pump is supplied by the equipment with 230V power supply. A circuit breaker (Q08) protects the turbo pump.

See **fig. 7** in appendix for turbo pump vacuum circuit.

CHAPTER 5. SYSTEM SETTINGS-UP

CAUTION

Some subsystems are powered inside the system. Factory-trained technicians should carry out these operations.

5.1. ADJUSTING THE INLET GAS FLOW FOR EACH MFC

The **inlet gas pressure** of each mass flow controller must be adjusted according the maximum inlet pressure and to the inlet differential pressure supported by the mass flow controller. A higher or lower inlet gas pressure could result in **instability of gas regulation**.

Information on inlet gas pressure is given in the **calibration certificate** of the MFC, which is provided with the system documentation.

5.2. ADJUSTING THE RELIEF VALVE

See **fig. 8** in appendix for water circuit representation.

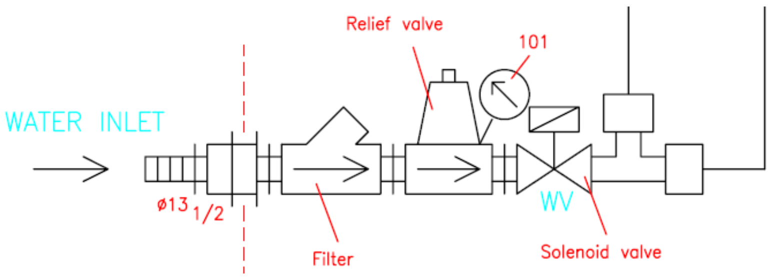
Adjusting the water pressure

Prior to any start-up or whenever the machine has been stopped for an extended period of time, it is necessary to check and adjust the water pressure in the water circuit.

To get the best running conditions, the water pressure droop in the system (between water inlet and outlet) must be about **2 bars**.

If the water outlet is at atmosphere, follow this procedure:

- Unscrew completely the adjusting screw of the relief valve;
- Supply the water on the cooling circuit;
- Tighten the screw of the pressure-reducing valve till you achieve 3 bars pressure on the manometer (101).



If the equipment is connected to a cold water network:

- Unscrew completely the adjusting screw of the relief valve;
- Supply the water on the cooling circuit;
- Tighten the screw of the relief valve till you achieve 3 bars pressure on the manometer;
- Water outlet must not exceed 1 bar to be sure the water flow will be sufficient.

CAUTION

If water outlet pressure exceeds 1 bar please contact QUALIFLOW THERM.

5.3. ADJUSTING THE PYROMETER EMISSIVITY

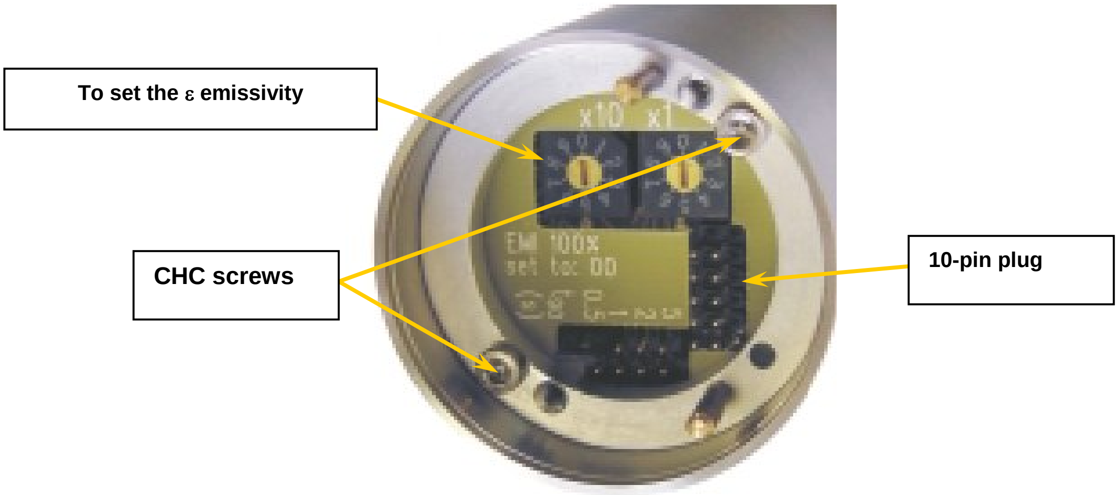
The JetFirst system is equipped with one pyrometer, high temperature or low temperature. The adjustment of the pyrometer emissivity needs to be done physically on the device. For further explanations on pyrometer settings, refer to the pyrometer **user's manual** provided with your system.

See **fig. 10** in appendix for pyrometer mounting location.

This pyrometer has a cover at the bottom, set with two CHC screws. Unscrew them and you will have the following configuration that will let you setting the emissivity of the pyrometer. Be careful when you take the cover out of the pyrometer as the cover is connected to 10-pin plug.

Typical settings on the pyrometer:

- x10 factor = 2
- x1 factor = 0



Calibration procedure for pyrometer is provided section 8.8.5 of this manual.

5.4. INSTALLING THE THERMOCOUPLES

Up to three thermocouples can be installed under the wafer through O-ring connectors, located under the reactor platen.

Threads are mounted in a stainless steel sheath and connected to a compensated plug. Tightness is obtained by an epoxy paste.

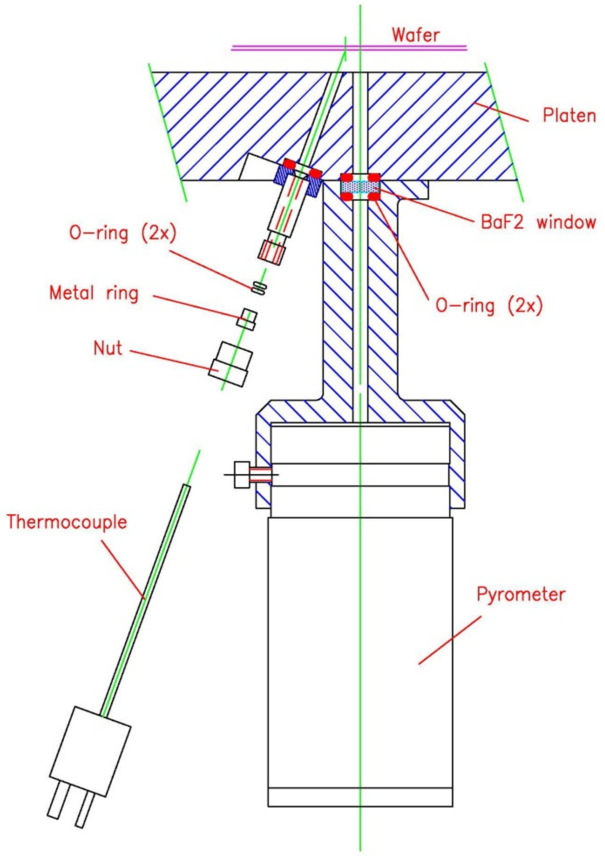
CAUTION

Thermocouple 1 (TC1) needs to be connected at any time. Only position of thermocouple 1 (TC1) has to be adjusted depending on process temperature. Move it down (but do not disconnect it) for process under pyrometer control at high temperature (>1000°C).

See **fig. 10** in appendix.

Proceeding:

- **Switch off** the machine and place a wafer in the reactor on quartz pins;
- Remove the left **metallic panel** (fixation by magnets);
- Under the platen you can see stainless steel **feed through** with Viton O-ring;



- Remove the **nut**, the small metallic **ring** and the two **O-ring**;
- Take the thermocouple place primary the nut, then, the ring and finally the two O-ring;
- Place this assembly inside the feed through very **carefully**;
- Push this till the welding threads **touch the wafer** installed on the quartz pins;
- **Screw the nut** to have the tightness;
- It is possible to readjust the thermocouple position to have a good contact with the wafer;
- Follow the same procedure in reverse order to remove the thermocouples.

5.5. ADJUSTING THE AIR PRESSURE SWITCH

The compressed air pressure must be adjusted to 6 bars.

Proceeding:

- Supply the system with compressed air;
- Remove the metallic panel on the left side;
- The compressed air switch (PFS) is besides the solenoid valve;

- Power up the system;
- Use the brass screw on the pressure switch to adjust it (the screw is placed between blue and red marks);
- Go to **Maintenance mode** and display controller inputs status;
- At 6 bars the air pressure indicator should be green and at 4 bars it should be white;
- Adjust the screw of the pressure switch until you get this result;
- Re-install the metallic panel.

CHAPTER 6. SYSTEM START-UP

6.1. BEFORE START-UP

IMPORTANT NOTICE

Before start-up, read the whole user's manual and check all facilities and fittings to the system.

Pre-starting operations have to be carried out by trained and habilitated personnel.

Procedure:

- Before start-up, read the whole user's manual;
- **Check all connections**: Electricity, gases, air, water;
- Place **thermocouple TC1**. Depending on process temperature control, pyrometer or thermocouple, install other thermocouples TC2 and TC3. Do not use thermocouple control for process at high temperature (>1000°C). See **section 5.4**.

6.2. START-UP OF THE SYSTEM

Procedure :

- Check electricity, water, air and gas supplies;
- Arm the main circuit breaker on the rear side of the system;
- Switch ON the system using the green press button;
- Start the computer and run the PIMS software;

6.3. RUN A PROCESS

IMPORTANT NOTICE

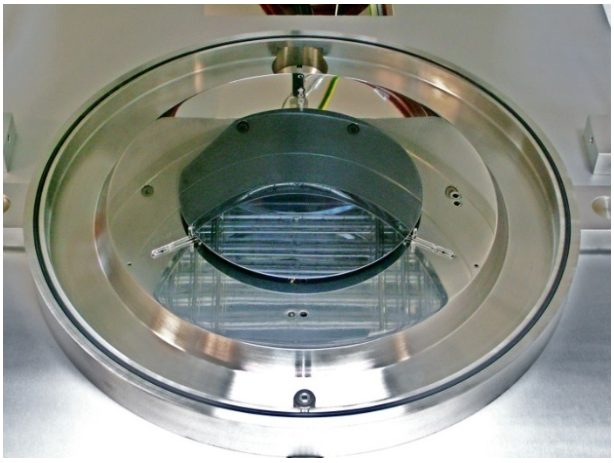
Before running a process, points stated out at chapters 6.1 and 6.2 should have been performed, checked and validated by trained and habilitated personnel.

To run a process, recipe should have been edited and downloaded into the PIMS software. See **section 8.3** for full information on recipe edition.

Procedure to run a process recipe:

- Select the required **quartz pins**. The JetFirst system is delivered with 3 sets of beveled quartz pins with different height depending on size substrate to be processed;
- Lift-up the reactor box, the platen appears. Place the quartz pins with a tweezers or with fingers (using gloves). See **fig. 11** in appendix;

- Install the sample on quartz pins.



- Close and lock the chamber using the black handle
- Select the **recipe** to be processed
- Select the PID table according to process conditions (sample type, susceptor, thermocouple or pyrometer control, vacuum conditions,…)
- Run the process.

CAUTION
While closing the chamber, take care of mechanical pinch hazard to ones fingers and from objects between top and bottom flanges. The locking chamber operation is manual.

6.4. END OF PROCESS

CAUTION
At the end of the process and cooling cycles, the sample and the top flange quartz window can remain hot. Wearing thermal gloves is mandatory.

At the end of the process, the system runs automatic sequences:

- Cooling cycle runs for 4 minutes ;
- Loading door handle sets free when reactor opening temperature is reached. See **chapter 8.6.2** for opening temperature configuration.

At the end of the cooling sequence and once reactor opening temperature is reached, ones can unlock the chamber and take out the sample.

NOTICE
If system is running dangerous gases such as NH_3, H_2 or others, at the end of the process, the system runs an extra pumping/purging cycle, repeated 3 times within 4 minutes time.

CHAPTER 7. SAFETY FEATURES

The machine is equipped with a full set of safety features, according to each component specifications.

All major components of the system, regarding to safety, are controlled by safety sensors.

7.1. FAILURES ACTION LIST

Here is a list of the safety features installed on the machine for each component:

Failures	Safety devices	Action on…
IR lamp failure	Two current sensors are installed on each zone, detecting the intensity difference between each pair of lamp inside a zone. A pair of lamp sets one zone.	Automaton
Heating zone controller failure	Each zone of lamps is powered by a thyristor with its own circuit breaker	Main safety loop
Furnace cooling fan	Fan circuit breaker	Main safety loop
Furnace overheating.	A temperature thermostat installed on the reflector controls the overheating	Main safety loop
Emergency stop button	Emergency stop on front face	Circuit breaker cut-out
Primary pump	Auxiliary contact on circuit breaker	Automaton
Turbo pump	Malfunction alarm from turbo pump	Automaton
Compressed air failure	A pressure switch controls the air flow	Main safety loop
Water failure	A water flow sensor is installed	Main safety loop
Door switch	Mechanical position switch	Main safety loop

All sensors connected to automaton are limited to process running control. There is no hazard for the user.

The software also manages a large number of safeties; check **section CHAPTER 9** for further details.

7.2. EMERGENCY STOP

The stopping procedure is declared when you press the EMO button.

Action on the equipment:

- Power to the lamps is OFF;
- Water cooling cycle of the reactor is ON;
- System is in STOP mode. Front face button is OFF.

CAUTION

General circuit breaker remains ON, system is still powered on.

CHAPTER 8. SYSTEM SOFTWARE CONTROL – PIMS

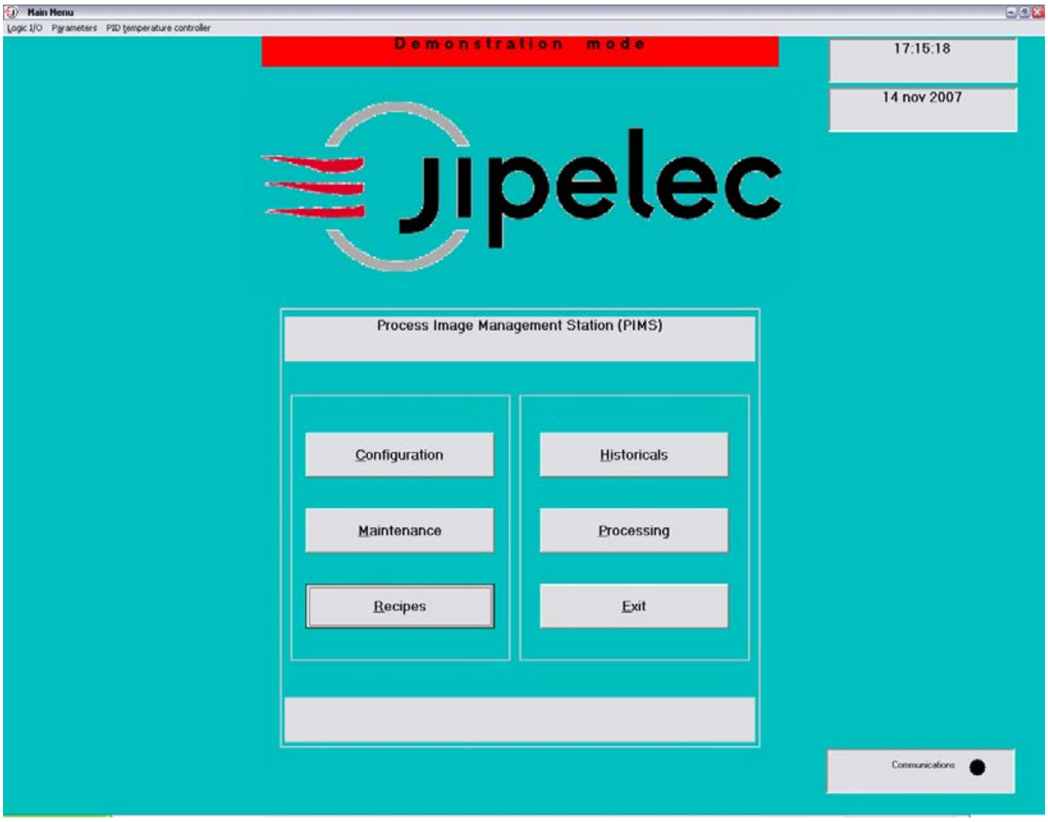
8.1. MAIN INTERFACE

The PIMS software provides easy programming control and monitoring of the JetFirst system. To use the PIMS control, the operator must select this mode in the main menu of the JetFirst.

The computer is the interface between the system and the operator to:

- Give process parameter to the system controller;
- Receive data and getting visualization during process;
- Store process data and monitor them again after process.

Software options can be chosen either with mouse and pressing the left button when key is selected on the screen or by using the keyboard by pressing at the same time key "**Alt**" and the underlined letter.



The main interface offers 6 operating commands:

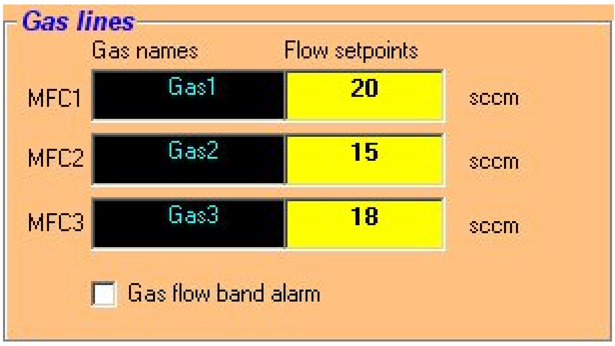
- **RECIPES** — to create, modify, display or delete a recipe;
- **PROCESSING** — to load a recipe and run a process;
- **MAINTENANCE** — for manual control of the system;
- **HISTORICAL** — to display saved process historical and alarm events;
- **CONFIGURATION** — to enter calibration tables, configuration parameters, etc;
- **EXIT** — to return to "WINDOWS" and to terminal control.

Initially, the software is in **engineering** mode and a message is displayed on the main menu form. The system will remain under **engineering** mode until the user changes the mode to **demonstration** or sets up passwords in the **Configuration menu**.

When the system is in **engineering** mode the operator can access to all operating modes.

8.2. COLOR CODE

In the step edition dialog, each parameter field has the **same color code**. When you enter a **value**, the field becomes **yellow** till it is not checked or validated by the PIMS.



If the value range is **correct**, the field becomes **white**. It means that the value has been accepted.

If the value range is **wrong**, the PIMS will return an **error message** to inform you that the value entered is not in the definition range. Once you click on "**OK**", you will see the cursor **located in the field** that contains the wrong value. Change this value and try again.

NOTICE

This software uses tool tip text feature. To get more details on a button, command or field, place the cursor on the required element. A tool tip text will appear.

8.3. RECIPE MODE

8.3.1. Recipe manager

This menu allows **creating**, **modifying**, **deleting** or **displaying** recipes.

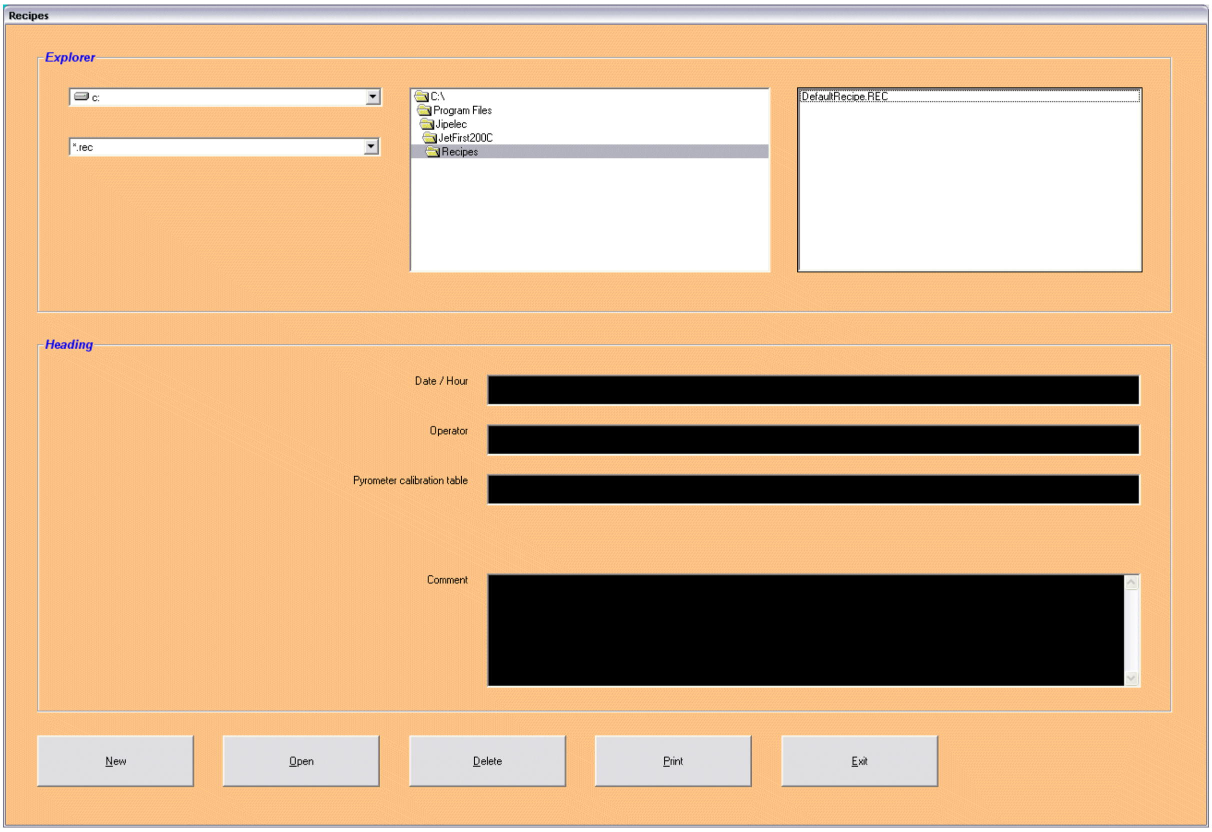
Each recipe is made of:

- A name;
- Up to 200 steps;
- An associated pyrometer calibration table.

Recipes are saved as ASCII files and can be prepared on any other computer. They also can be saved in different directories on the computer.

When the operator enters the **Recipe mode**, he can select one of the recipes in the recipe list for modification or create a new recipe.

The following dialog box displays recipe configuration in the **Heading** field. This field will remain the same for the whole duration of the recipe. These details only appear if an existing recipe is selected from the **Explorer** (upper part of the dialog box).



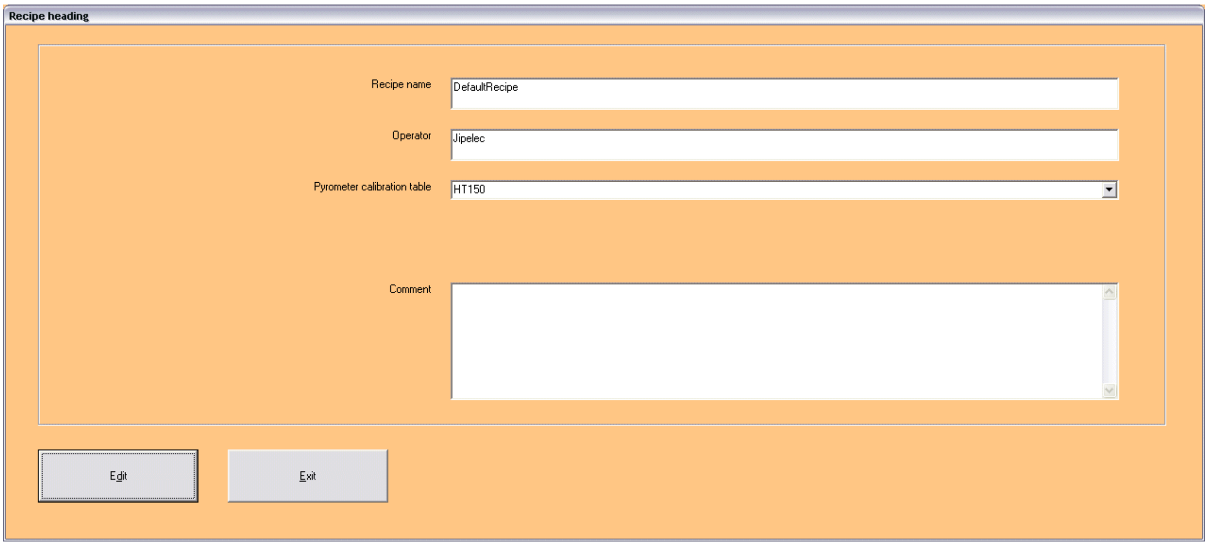
CREATING A RECIPE

When creating a new recipe, some parameters have to be entered; some others are optional.

Parameters:

- Recipe filename;
- Pyrometer calibration table;
- Operator's name (optional);
- Comment (optional).

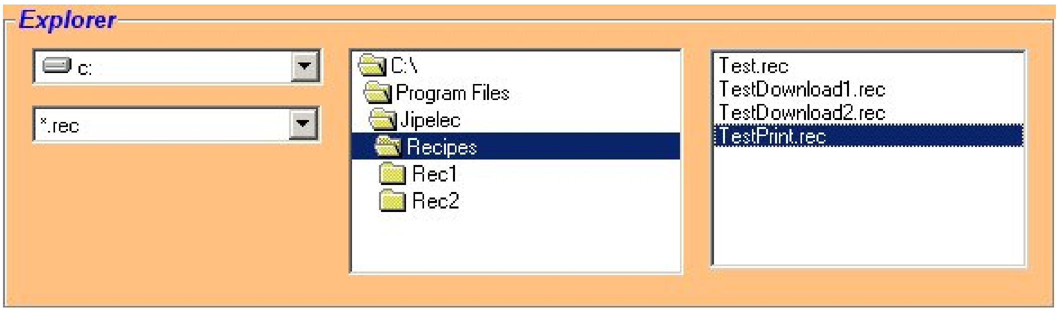
To create a new recipe, press the command button "**New**". The following dialog box will appear to enter the recipe file information and parameters listed above.



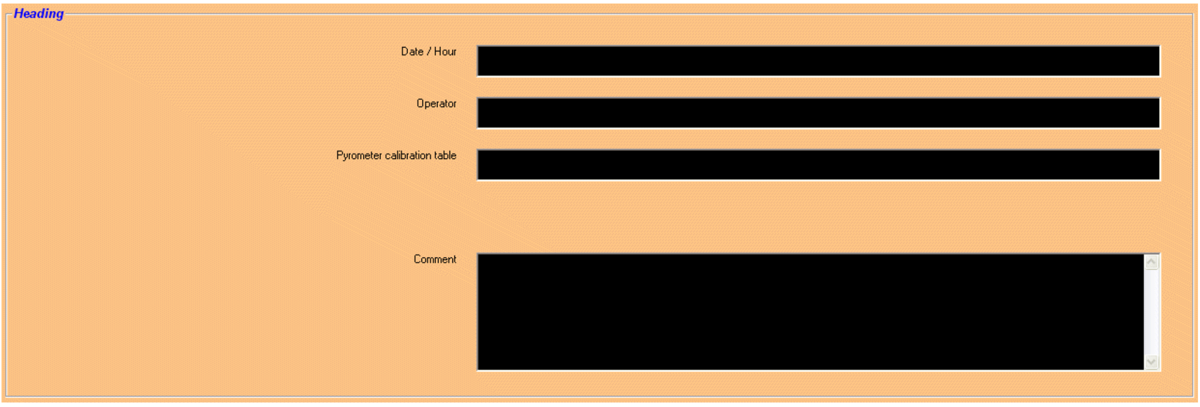
Once the recipe information entered, the command button "**Edit**" will display the **recipe edition interface**. See **section 8.3.2** for detailed explanations.

OPENING A RECIPE

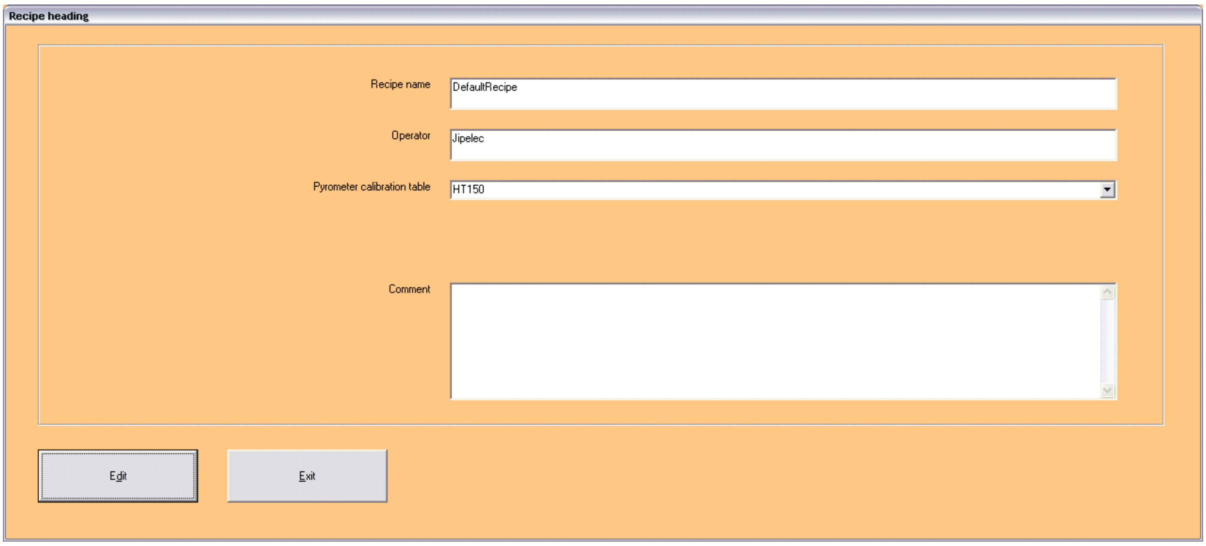
To open an existing recipe file, you first need to select the recipe file using the **Explorer** field of the dialog shown below. Depending on the recipe file location on the computer, you may need to browse different directories and hard disks. The standard recipe directory is **C:\Program files\Jipelec\JetFirst\Recipes**



Once the recipe file selected, you can see its identification card displayed in the **Heading** field of the dialog.



To enter the recipe, press "**Open**". The following dialog box appears to let the operator changing the heading information if required.



Once the recipe information modified, the command button "**Edit**" will display the **recipe edition interface**.

COPYING A RECIPE

You can create a new recipe from an existing recipe. The trick is to open an existing recipe and save it as a new recipe filename.

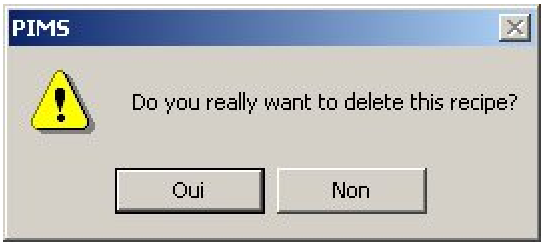
Proceeding:

- Select an existing recipe in the **Explorer** field;
- Click on "**Open**";
- In the **Recipe heading** dialog, change the recipe filename;
- Then click on "**Edit**";
- Once the **Editing interface** entered, press the command button "**Save recipe**";
- A warning dialog appears to confirm that the recipe file is saved.

When you enter again in the **Recipes** window, the new recipe file created will appear in the list of the **Explorer** field.

DELETING A RECIPE

To delete a recipe, select the recipe from the recipe **Explorer** and click on "**Delete**", the following confirming dialog appears.



PRINTING A RECIPE

To print a recipe, select the recipe in the scroll list and click on "**Print**", the following confirming dialog appears.

Pressing the command button "**OK**" will display the standard Microsoft Windows printing dialog box.

8.3.2. Recipe edition interface

For each step the operator can edit or change:

- Temperature setpoint;
- Duration of step (in seconds or tenth of seconds);
- Temperature control mode (pyrometer, thermocouple or power);
- Enter compensation coefficients on power for each zone;
- To open or not vacuum and purge valves;
- To switch on/off the temperature band alarm;
- To set on/off the gas flow band alarm;
- Gas line mass flow controller setpoint;
- A comment for the actual step (optional).

Some parameters are only available with optional modules installed on the system. For instance, "*Secondary vacuum*" parameter is available with a turbopumping unit and "*Butterfly valve setpoint*" with a pressure regulation module.

To display the **Step** edition dialog box, create a new recipe or choose an existing recipe.

To **select options**, use the mouse and click with the **left button**. Click on to change the status of the option. Click on once more to return to previous status.

STEP CONTROL TOOLS

Step browser

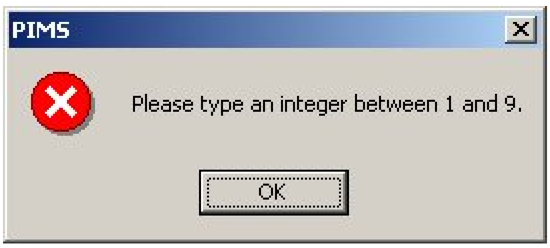
Several buttons are directly dedicated to step browsing inside the recipe: "**Previous step**", "**Next step**", "**First step**" and "**Last step**". These four buttons allow the user to go from one step to another or jump to the first or the last step directly. Only the "**Next step**" button has got two functions (see the *Notice* below for details).

Notice:

- If you display the **last step** of the recipe and press the "**Next step**" button, the following warning message pops up to ask you if you want to add a new step at the end of the recipe. If you click **YES**, a new step will be added to the recipe.

This message only appears once when you open an existing recipe file. If you click again on "**Next step**", a new step will be added without any warning message till the recipe is saved and the **Recipe** mode exited. If you open another recipe, the warning message will appear if you click on the same button.

- In the field "**Go to step number**", enter a number of step, which exists in the recipe, and press the **ENTER** key. If you enter a number of step that doesn't exist in the recipe, the following warning message appears, giving the range between the first and the last step of the current recipe:



Step managing

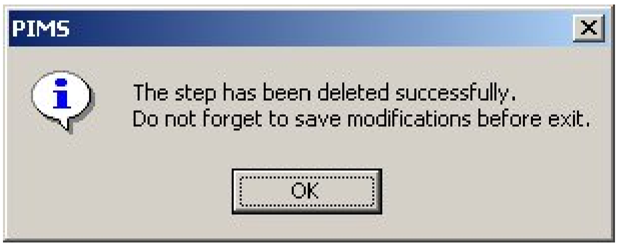
"**Insert step**" will insert **without warning** a blank step before the current selected step.

"**Delete step**" will delete **without warning** the selected step displayed on screen.

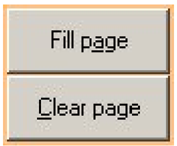
Note:

- When you insert a **blank step**, the following message pops up:

- When you **delete a step** the following message pops up:



Step editing



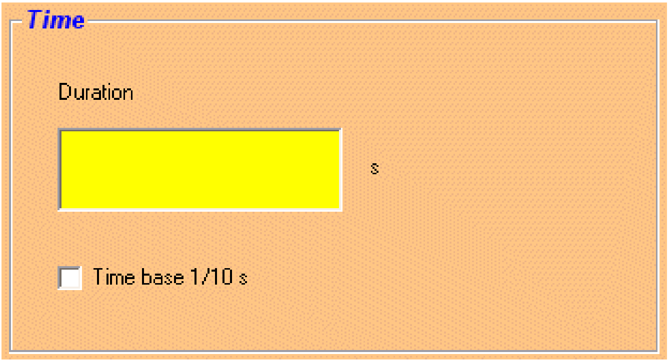
"**Fill page**" will copy **without warning** each parameter's value from the previous step.

"**Clear page**" will reset **without warning** all parameters' values to blank for the current step.

Note:

- When you **edit a step**, you cannot go to another step if the "**Step duration**" field is not completed. A warning message will appear if a time length is not entered:

… and focus (cursor) passes to the step duration field that is highlighted in yellow:



- If you display a step already filled and press "**Fill page**", this command will copy the parameters of the previous step **without warning**. So it will **erase** the parameter's values of the current step.

STEP COMMENT

For each step, the user can enter a **comment**, with an unlimited number of characters.

The **recipe name** (or recipe filename) only appears when the recipe has been saved or when you open an existing recipe.

8.3.3. Entering parameters

GENERALITIES

A full set of parameters can be adjusted from one step to another.

It is also possible to choose some other parameters:

- Temperature control mode: pyrometer, thermocouple or power;
- Temperature setpoint;
- Compensation coefficients on power for each zone;
- Time base (1 second or 1/10 second);
- Gas line 1 mass flow controller setpoint;
- Gas line 2 mass flow controller setpoint;
- Gas line 3 mass flow controller setpoint;
- Gas line 4 mass flow controller setpoint;
- To open or not the purge valve;
- To open or not the vacuum valves (primary / secondary vacuum);
- To enter or not a butterfly vacuum valve setpoint (for pressure regulation);
- To activate the temperature band alarm;
- To activate the gas flow band alarm.

TEMPERATURE

During process, temperature can be ramped or dwelled. The initial temperature is the final temperature of the previous step or ambient temperature for first step. The step's final temperature is the displayed temperature.

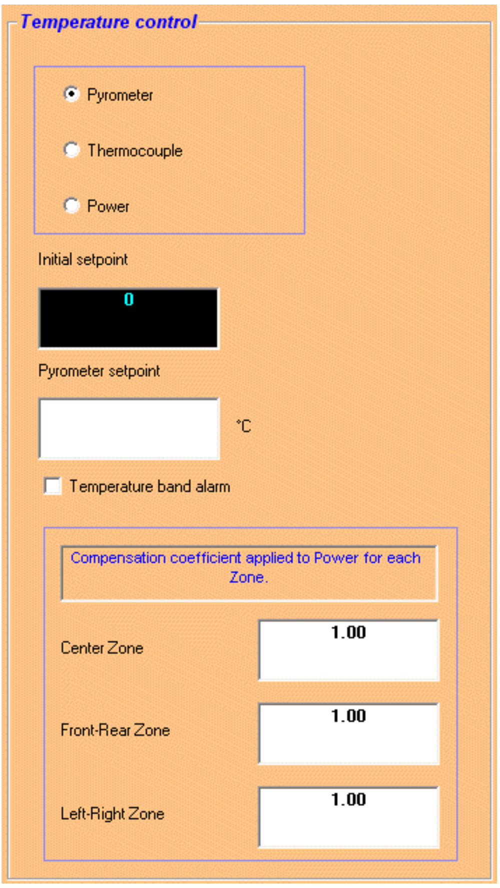
In **power mode**, power can be set from 0% to 100%.

CAUTION

When using power mode there is no temperature control and you may damage your samples, or melt them in a few seconds if power is too high.

The ranges for parameters are:

- Temperature: 0-1300°C;
- Time: 0-9999 s;
- Gas setpoint: up to MFC full range.



This mode allows choosing the sensor for the temperature control mode:

- The thermocouple is used for low temperature processes and to perform the pyrometer calibration. The thermocouple cannot be used with active gases (H_2) because they reduce its lifetime;
- The pyrometer is usually used for most of the processes.

During process, the system will display the temperature from the control sensor, even in **Power** mode.

CAUTION

Using the Power mode temperature control can reach high level and damage or destroy the sample. At 100%, a silicon wafer will melt in a few seconds.

Temperature band alarm

The temperature alarm limit can be set from 0 to 200°C in the parameters configuration mode. See **section 8.6** for further details.

If the temperature alarm limit is activated for a step, and if the difference between the setpoint and the temperature from the temperature sensor is over the temperature alarm limit, the system will display an alarm message. The temperature alarm limit must be activated for each step.

The configuration mode also allows configuring the software in order to stop the system if there is a temperature alarm limit.

COMPENSATION COEFFICIENTS

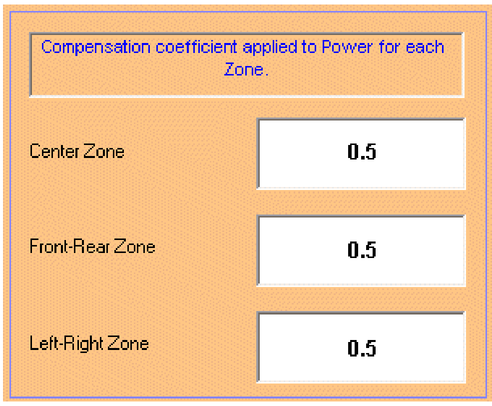
To improve uniformity, the third zone of lamps is perpendicular (or on the edge for JetFirst 200F) to the two first ones. This allows adjusting power on each zone with a compensation coefficient. The power is calculated by PID loop (RKC Module), and is applied to the center zone. This value can be increased or decreased on lateral zones. The power is just multiplied by the compensation coefficient.

*Example: Enter a temperature setpoint of 20% with t*he following parameters give as results:

INPUT PARAMETERS	OUTPUT EFFECTS
Center zone: 1 (with Power setpoint: 20%)	Center zone power = 20%
Front/Rear coef: 2.0	Front/rear zone power = 40%
Left/back coef: 0.5	Left/back zone power = 10%

So, for best adjustment, three compensation coefficients are added in recipe editor for each step.

For each zone (center, front/rear and left/right), this coefficient can be adjusted from 0 to 9.99 with a default value of 0.5.

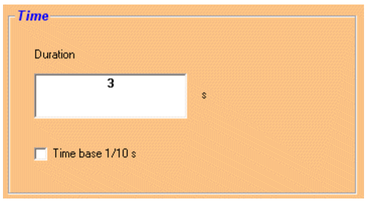


Note:

A coefficient value of 0.5 is typical for process temperature up to 600°C. For processes above 1000°C, use a coefficient value of 1.0 (no compensation on lamps).

TIME

Step duration from 0 to 9999 seconds.



It is possible to reduce the step time base by a factor of ten. This mode allows counting down step duration 10 times faster. (Example: if duration is 15 s the actual step duration will be 1,5 s).

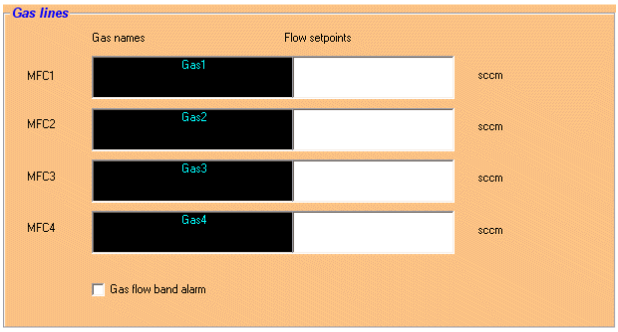
GAS SETPOINT

Gas 1 to 4 solenoid valves, allowing or not the gas to enter the chamber, will open if the mass flow controller setpoint is different from zero. The mass flow is set to the required value for the step. Gas line number 2 is dedicated to active gas.

WARNING

If your system is equipped with H_2 and O_2, gas mixing is forbidden by a soft interlock. Entering simultaneously gas flow setpoint for H_2 and O_2 is not allowed and if ones do so, an error message pops up.

If system is supplied with pure hydrogen, in the recipe, prior to entering H_2 setpoint in a step, ones has to create a step of pumping at < 50mbar for 10 seconds. If not done, the PIMS will raise the "H_2 interlock" during the process and stop the process.



WARNING

During the different recipes, the user has to take great care about gas mixing. Use of O_2 and H_2 gas flow includes a soft safety sequence:

- One step that uses H_2 injection has to follow with one pump step at <50 mbar during at least 10 sec before any step using O_2 gas flow.

- One step that uses O_2 injection has to follow with one pump step at <50 mbar during at least 10 sec before any step using H_2 gas flow.

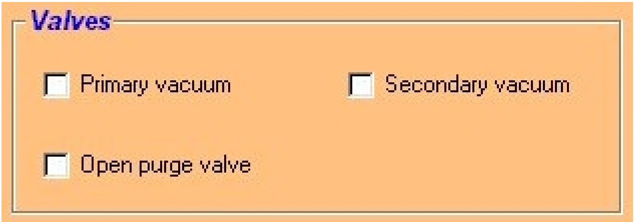
Gas flow band alarm

The gas alarm limit can be set from 0 to 20% in the parameters configuration mode. See **section 8.6.2** for further details

If the gas flow alarm limit is activated for a step, and if the difference between the setpoint and the gas flow is over the alarm limit, the gas name will flash in yellow color. The gas flow alarm limit must be activated for each step.

VACUUM VALVES

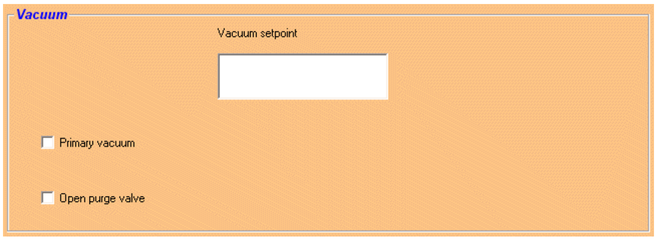
The vacuum valves can be opened at each step of a recipe for purge or vacuum process under primary and/or secondary vacuum.



WARNING
The secondary vacuum pump must not be used in process when the temperature inside the chamber is over 90°C. You could damage or break the turbo pump.

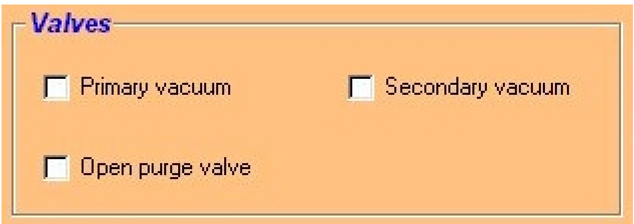
Pressure regulation

If a pressure regulation module is installed, one can enter a pressure setpoint in mBar.



PURGE VALVE

The purge valve can be opened at each step of a recipe for purge or vacuum process. If the purge valve is closed, gas will go out of the chamber through the exhaust line.



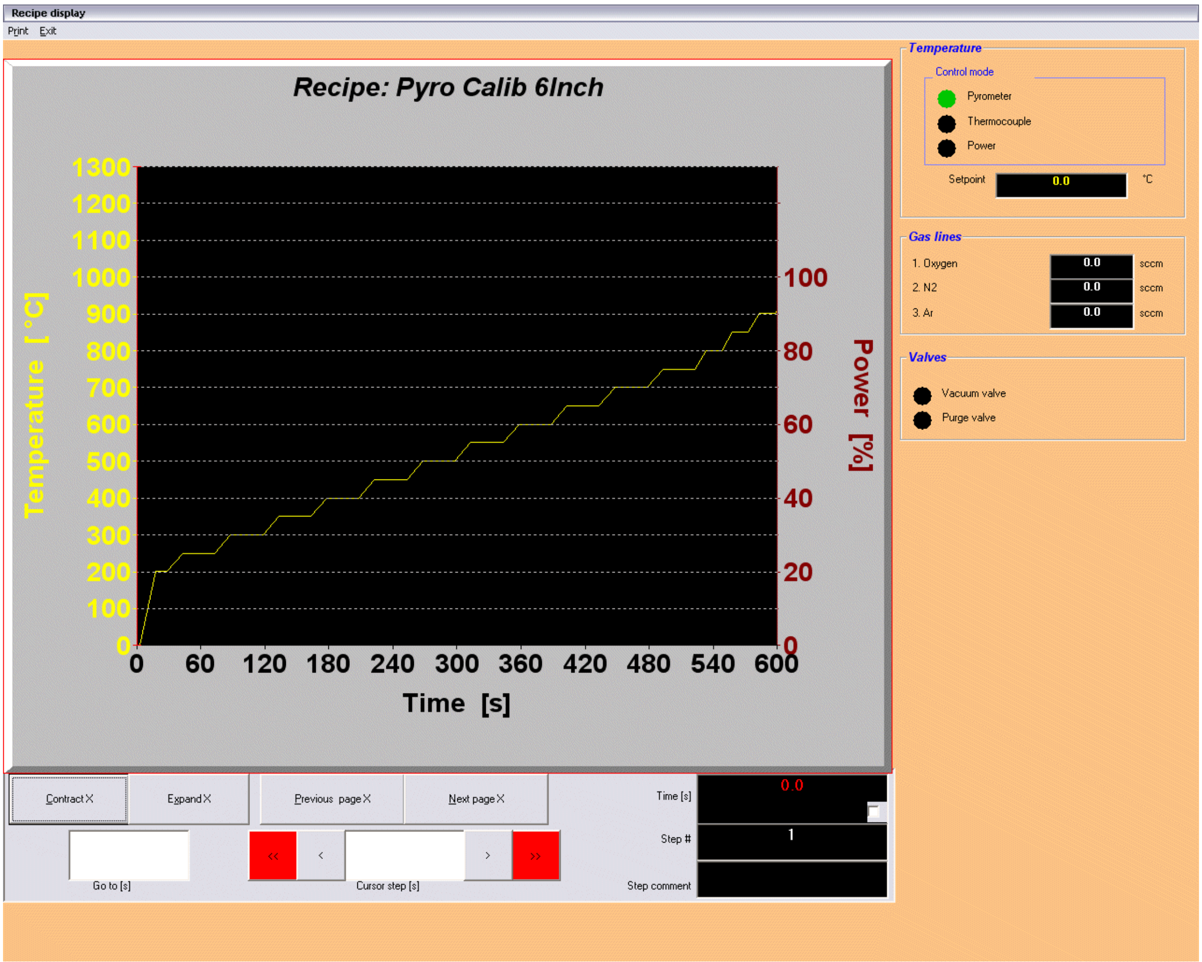
8.3.4. Recipe display

An existing recipe or recipe under construction can be displayed from the recipe step page. This can be useful to rapidly scan a recipe and check the thermal profile for instance.

The graphical window is fully **customizable**. You can enter your own parameters for scale ranges, text format, graph type, etc… To change those parameters, just **double-click** on the element with the **left mouse button**.

To display a recipe:

- choose the **Recipes mode**;
- Select an existing recipe;
- Edit the recipe;
- In the step screen, click on "**Display recipe**" button.



A new screen is displayed with a graph window for temperature as a function of time. On the right, the numerical values for the other parameters of the recipe are presented (gas flows, temperature control and valves status).

Toolbar:

The time scale can be contracted (**Contract X**) or expanded (**Expand X**) from 0,1 s to 15s minimum and 4800 s maximum. If the recipe total duration is longer than the X scale, the buttons "**next page**" or "**previous page**" allow displaying the out-scale windows.

It is also possible to shift a bar by the steps with the "**Cursor step**"; the corresponding time is displayed at the black window on the lower part of the screen. In this case, the numerical values of the other parameters will evolve with the step time. Small arrows (<,>) displace the cursor by a fix time of 1 s; double arrows (red window <<, >>) displace the cursor by a time defined in the cursor step window, which can be smaller than 1 s (0,1 to maximum x value). This displacement is performed within the time of the displayed page; at the end of the X scale, you must click on "next page" to visualize the following steps.

Two commands are available in the top left corner. "**Print**" will send curves and parameters to your printer, while "**Exit**" will return to the "**Edit steps**" window.

Recipe saving and exit

The following command buttons ends your recipe edition. First save the recipe and then exit from the **Recipes** mode.

To save your recipe once edited, press the command button "**Save recipe**". The following dialog appears.

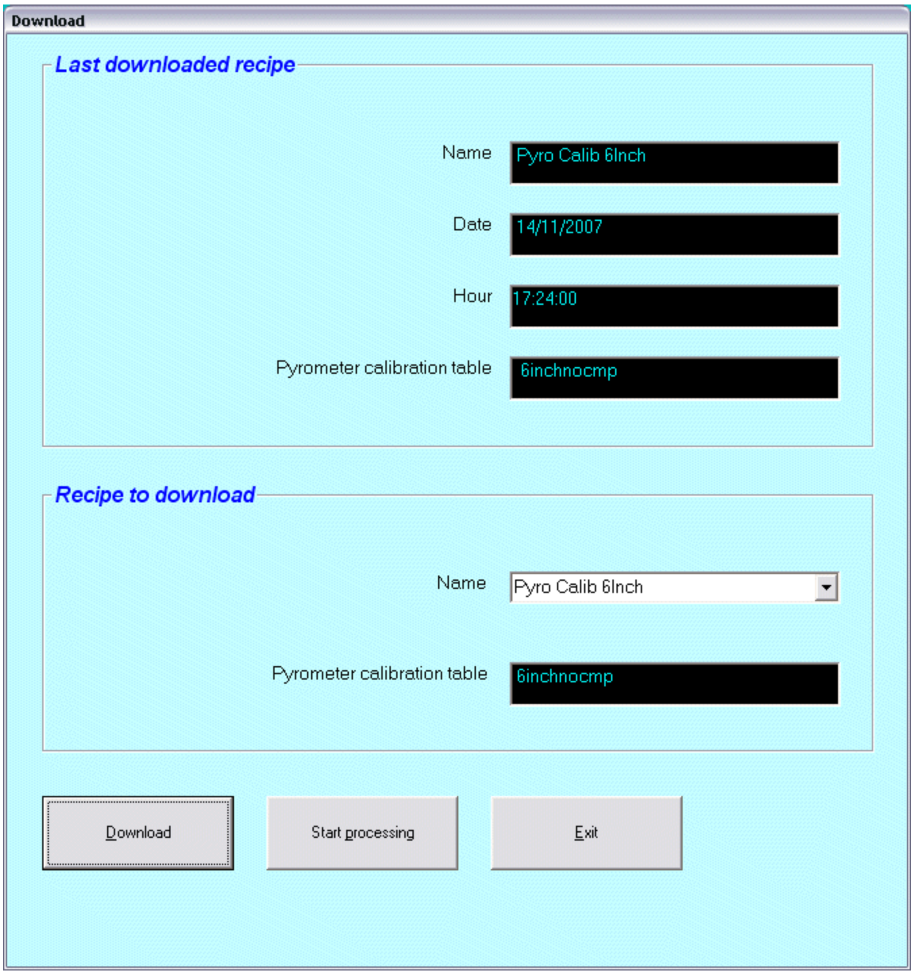
When pressing the "**Exit**" command, a confirmation dialog appears as follows. If the recipe is not already saved, click "**NO**" and save your recipe using the command button "**Save recipe**".

8.4. PROCESSING MENU

Before running a process, check:

- Water supply;
- Gas supply;
- Compressed air;
- Vacuum pump.

Select process mode with key “**PROCESSING**”.



8.4.1. Download recipes

All recipes are stored on the computer's hard disk. It is necessary to send parameters to the system controller before starting the process.

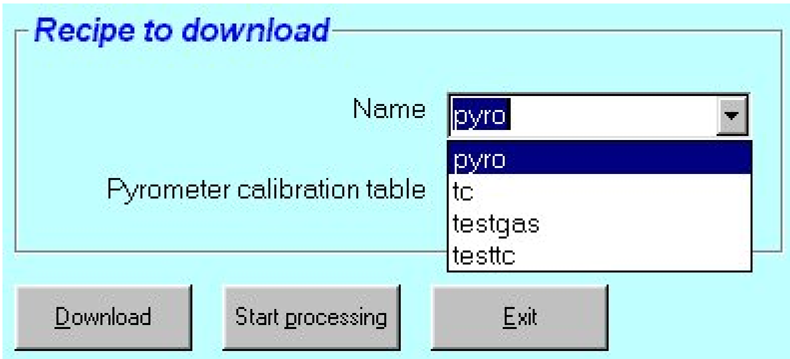
When the operator chooses process mode, the system will display the above **Download recipe** form, it will ask to download a recipe and then begin a process.

If the process to perform is the same as the last one that was downloaded to the system (displayed on the top of the form), the operator can start process immediately. Caution: if a parameter of the step has been changed the recipe must be downloaded once more.

If the recipe to process is different from the last recipe downloaded, then, downloading must be done before operation.

To download a recipe:

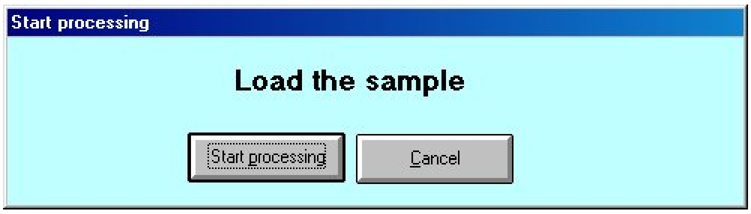
- Select a recipe to download in the list with the mouse;
- Select key "**Download**".



The associated calibration tables are also downloaded.

It is possible to return to the main menu by using key "**Exit**".

When downloading has been performed, press “**Start Processing**”. The system will ask for sample loading. If sample has already been loaded, it is possible to start process immediately.

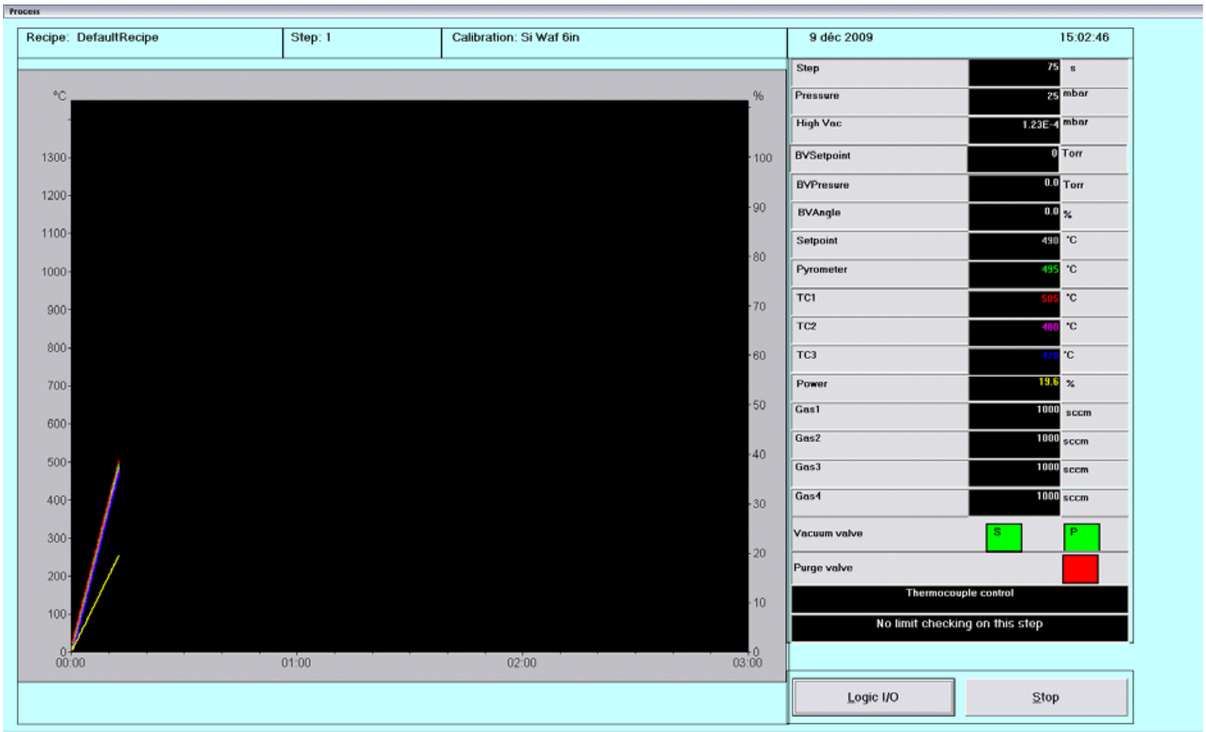


WARNING

DO NOT FORGET TO PLACE A SAMPLE IN THE REACTOR.

As the lamps are heating the sample only and not the air, you absolutely need to place a sample in the chamber before heating. You could seriously damage the equipment in such a case.

When "**Start Process**" is selected once more, the screen will display the process form and process starts immediately.



During process, the chamber is locked and remains locked until the temperature has reached the opening threshold (see configuration mode).

8.4.2. Process monitoring

During process, the screen displays all the parameters:

- Recipe name;
- Current step;
- Calibration table name;
- Setpoint;
- Temperature from pyrometer and thermocouple;
- Power to the lamps;
- Valves status;
- Vacuum pressure readings;
- Gas flow readings.

On the left part of the screen, a plotter monitors the curves of the setpoint, temperature sensors and the power to the lamps.

The color of the curve is the same color as the displayed value of the parameter.

- **White** Setpoint;
- **Green** Pyrometer;
- **Red** TC1;
- Magenta TC2;
- Blue TC3;
- **Yellow** Power to the lamps.

Valves status indicators:

- **White** the valve is not provided on this system;
- **Red** the valve is closed;
- **Green** the valve is open.

The screen also displays the temperature alarm limit, checking status and the temperature alarm limit message is the temperature that is outside the limit when this function is activated.

Process can be stopped at any time by using key "**Stop**".

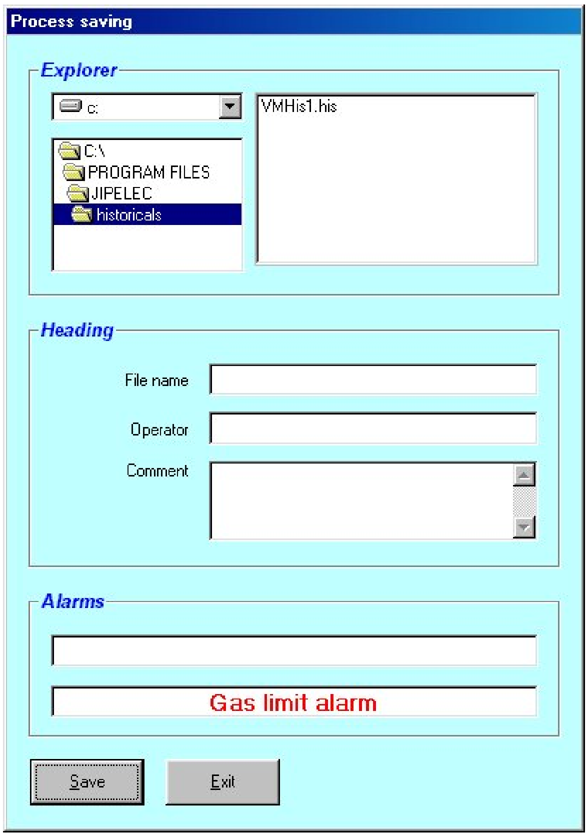
In case of gas alarm, the backside of the gas flow display will be **yellow flashing**.

8.4.3. Save Process

At the end of the process, the system is being cooled down for 3 minutes. Even during this cooling time, it is possible to save the process monitoring as a **historical** file.

To save the process historical, enter the following parameters in the dialog box below:

- Enter the recipe historical filename (up to 10 characters);
- Enter a comment (optional);
- Press "**Save**".



The historical is saved on the hard disk in the directory "**Historical**". They can be saved on floppy disk or in other directories by using Windows facilities. It will be possible to read the historical from any directory or driver in the historical mode.

The name of "**Historical**" directory must not be changed, because it is the default directory used by the software.

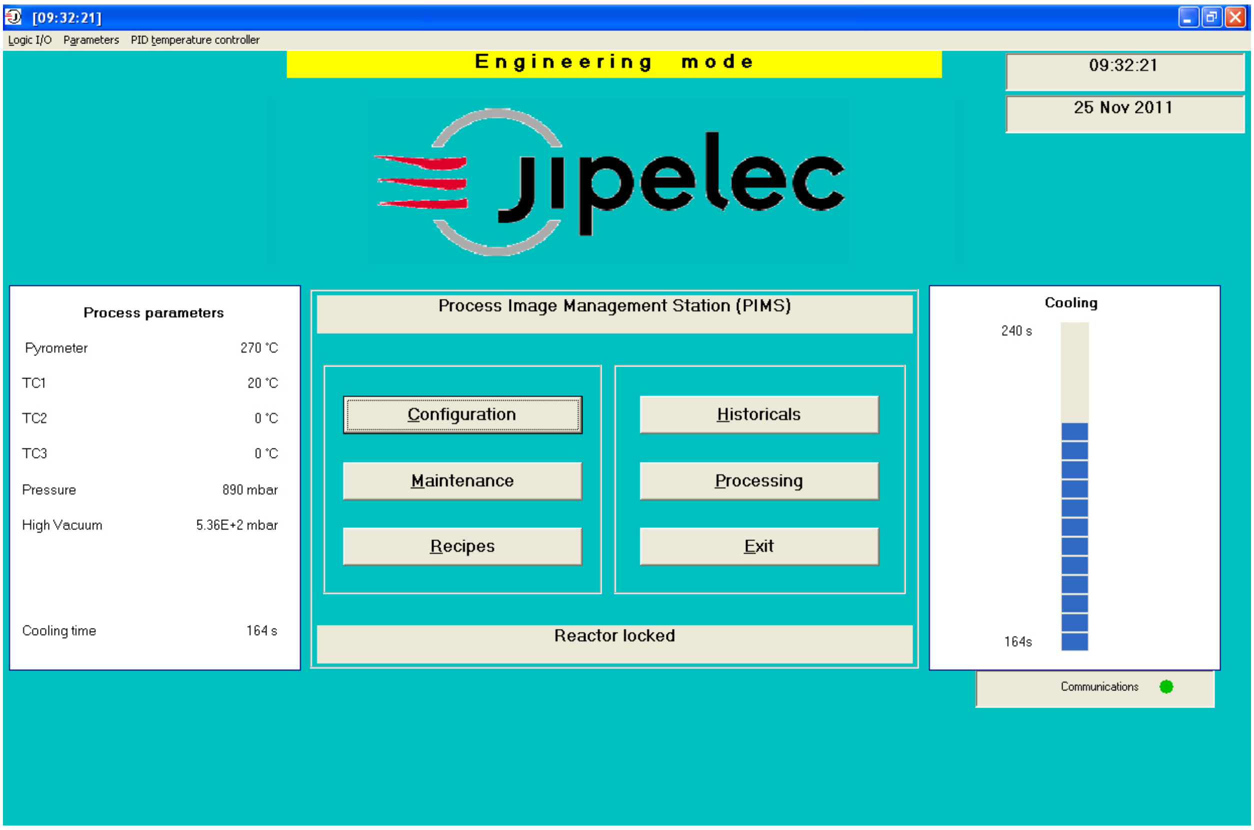
When the process has been saved, or if saving is not needed, press key "**Exit**" to return to the main menu.

If a gas alarm or a temperature alarm limit has occurred during the process it will be displayed on the save process form.

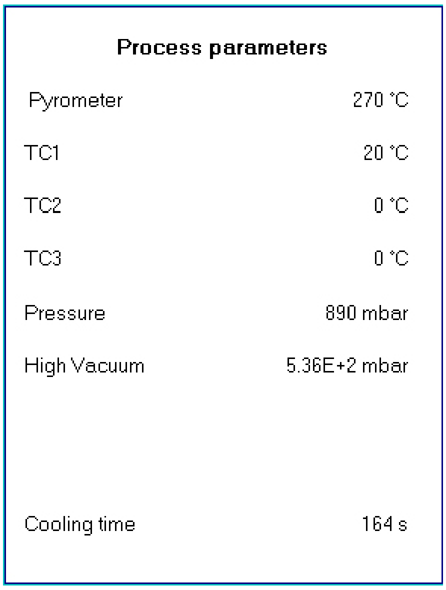
8.4.4. End of process

Once process is ended, cooling starts automatically for 240s. You can see on the left side of the main interface all cooling down parameters.

If the system is using active gases, such as hydrogen (H_2), a pumping/purge cycle is running at the same time as the system cools down.



On this table, you can check all pressure and temperature readout values:



8.5. MAINTENANCE MENU

DANGER

In MAINTENANCE MODE, all soft alarms are DE-ACTIVATED. Only qualified and trained technicians are allowed to run this mode.

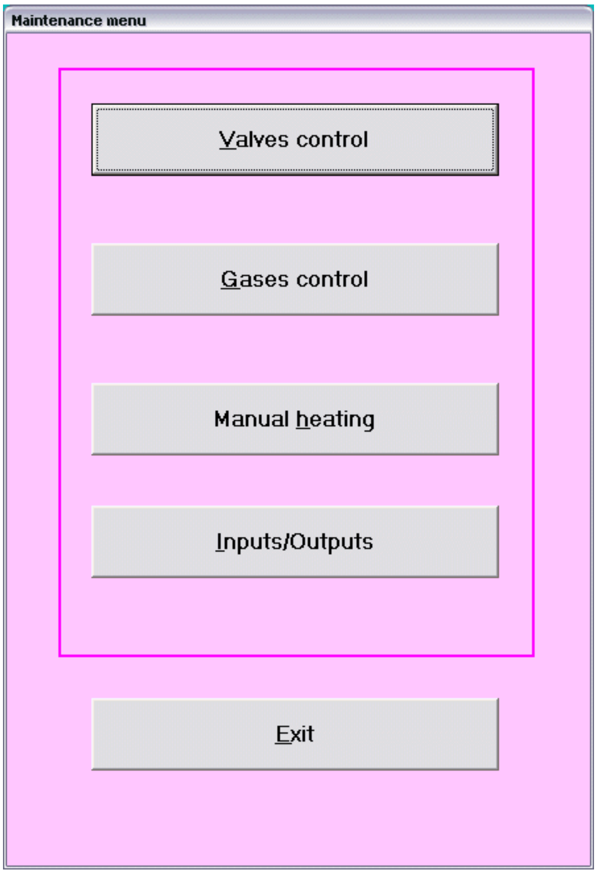
8.5.1. Menu

STANDARD MENU

The maintenance standard menu is so called for a system without turbo-pumping unit installed.

This mode is dedicated to maintenance operations and adjustments. The engineering mode password needs to be entered to access this mode.

When the **MAINTENANCE** mode is selected, the screen displays the **MAINTENANCE** form:



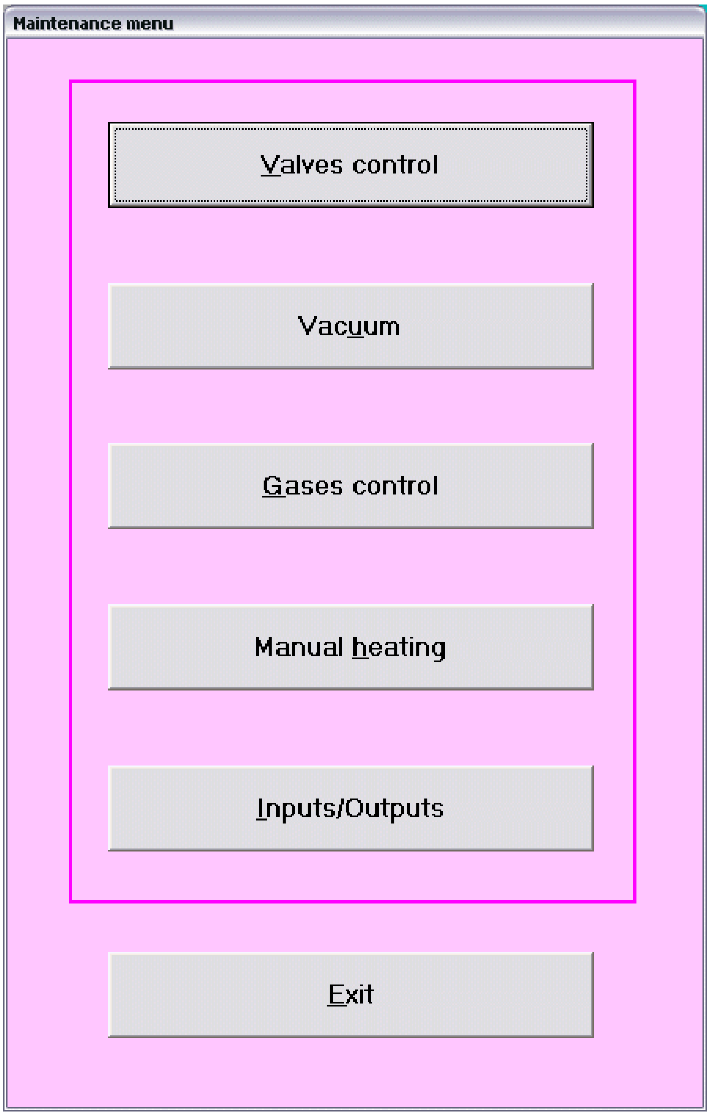
The maintenance mode allows:

- Setting the lamps at a fixed power;
- Controlling some valves and vacuum devices;
- Controlling mass flow controllers;
- Displaying controller inputs status;
- Regulating temperature under thermocouple or pyrometer control.

TURBO-PUMPING MAINTENANCE MENU

If a turbo pump is installed on your equipment, the “*Vacuum*” button is added. This button gives access to the vacuum synoptic. See chapter 8.5.3 for details.

This synoptic includes functions that allow starting and stopping vacuum sequences. It also provides readouts of vacuum gauges, gas flows and valves status.



8.5.2. Valves control

STANDARD VALVE CONTROL DIALOG BOX

*The **valves control** dialog box allows:*

- Switching ON cross-flow fans and water valve;
- Opening and closing the purge valve;
- Opening and closing the vacuum valve;
- Reading pressure inside the chamber.

The valve status indicator is:

- **Red** the valve is closed, fans are OFF or water flow not sufficient;
- **Green** the valve is open or fans are ON;
- **White** the valve is not provided on the system.

Going back to the menu will close all valves.

VALVE CONTROL DIALOG BOX FOR PRESSURE REGULATION

*The **valves control** dialog box allows:*

- Switching ON cross-flow fans and water valve;
- Opening and closing the purge valve;
- Opening and closing the vacuum valve;
- Reading pressure inside the chamber;
- Entering butterfly vacuum valve setpoint (mbar);
- Reading value of pressure and angle for butterfly valve.

The valve status indicator is:

- **Red** the valve is closed, fans are OFF or water flow not sufficient;
- **Green** the valve is open or fans are ON;
- **White** the valve is not provided on the system.

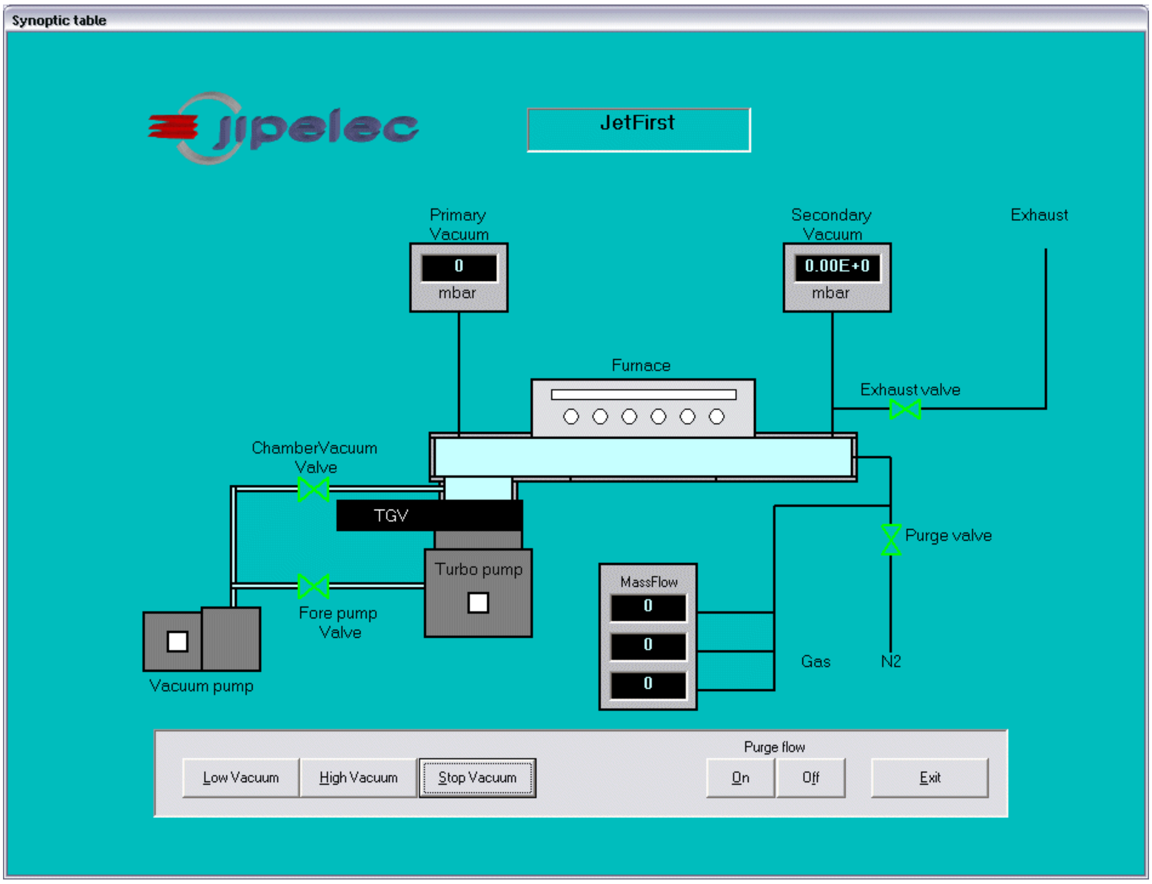
Going back to the menu will close all valves.

8.5.3. Vacuum synoptic

This “*Vacuum*” button displays a synoptic of the vacuum circuit. This option is only **available** if a **secondary vacuum unit** is installed on your system.

This synoptic includes functions that allow starting and stopping vacuum sequences. It also provides readouts of vacuum gauges, gas flows and valves status.

During pumping sequences, the exhaust isolation valve (EIV) is automatically closed if pressure is under 900mbar.



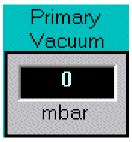
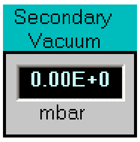
SYNOPTIC TOOLBAR

- **Low vacuum** Start a primary vacuum sequence;
- **High vacuum** Start a secondary vacuum sequence.
  In this case, the primary vacuum sequence is automatically launched.
- **Stop vacuum** Stop the vacuum sequence.
- **Purge flow** Start or stop the nitrogen gas flow by opening the purge valve (PGV)
- **Exit** Quit the synoptic and return to maintenance menu.

For safety reason, purge command is ignored if vacuum cycle is ongoing, and vacuum command is ignored if purge is ON.

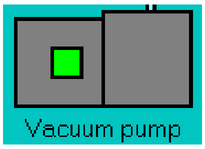
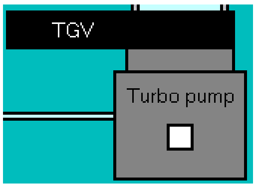
VACUUM READOUTS

Readouts of the vacuum pressure inside the system are displayed as follows.

Representation	Description
	Readout of the primary vacuum pressure.
	Readout of the secondary vacuum pressure.

VACUUM PUMPS STATUS

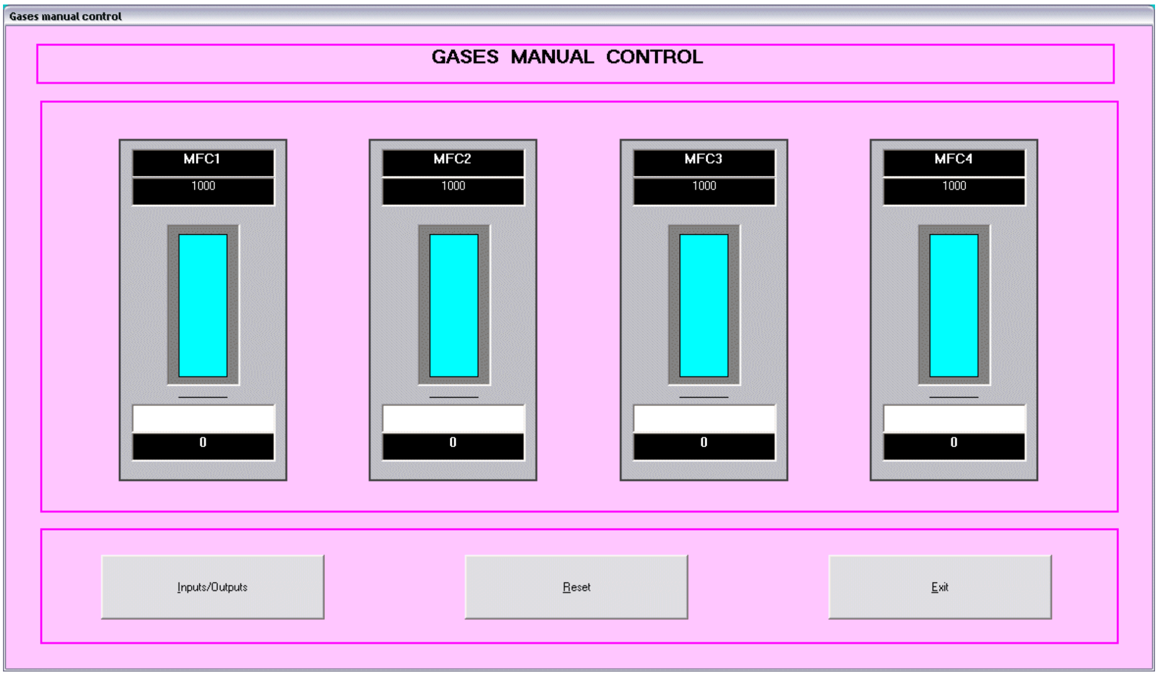
Color code is used inside the synoptic to give information on the primary and secondary pump status.

Representation	Description		Output signals
	The small white square shows the status of the pump: **White**: **Green**:	 Primary pump is OFF Primary pump is ON	 FPV = 0 FPV = 1
	The small white square shows the status of the pump: **White:** **Black:** **Green:** **Red:**	 Turbo pump is OFF Turbo pump is starting Turbo pump is ON Turbo pump under failure	 TPSS=0 TPSS=1 / RSA=0 / MFO=1 TPSS=1 / RSA=1 / MFO=1 TPSS=1 / MFO=0

See **section 8.5.6** for inputs / outputs table.

8.5.4. Gases control

This mode allows having a direct control on the **mass flow controllers**. The gas line valve opens if the mass flow controller setpoint is not null.



Procedure:

- Enter the **setpoint** to set the gas flow;
- Press the "**ENTER**" key to record the setpoint;
- The gas flow setpoints are displayed on bar graph and values.

Click on "**Exit**" to return to the maintenance mode menu, **reset all setpoints** and close the gas valves.

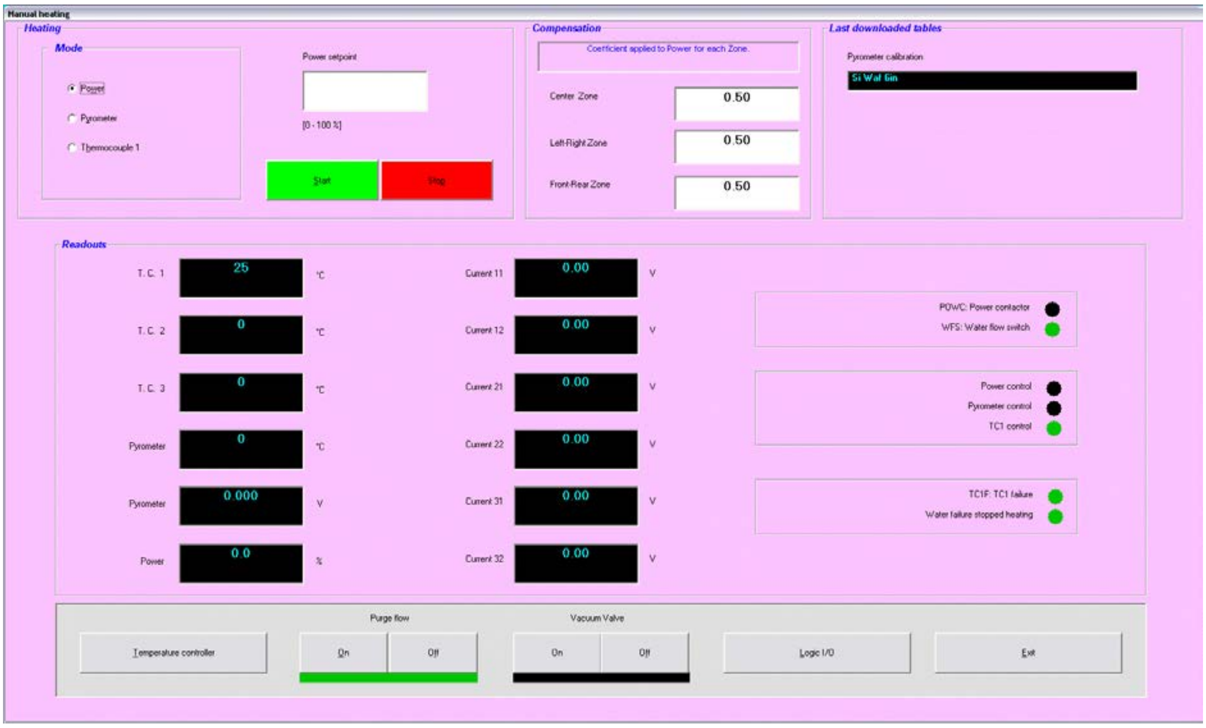
WARNING

If your system is equipped with H_2 and O_2, gas mixing is forbidden by a soft interlock. Entering simultaneously gas flow setpoint for H_2 and O_2 is not allowed and if ones do so, an error message pops up.

If ones use an O_2 or H_2 gas flow, a compulsory manual safety sequence is required. H_2 or O_2 injection has to follow with one pumping cycle till a pressure value <50 mbar, and wait for at least 10sec before any other gas flow. To do so, enter the MAINTENANCE MENU > VALVES CONTROL mode to start manually a pumping cycle. See chapter 8.5.2 for further details.

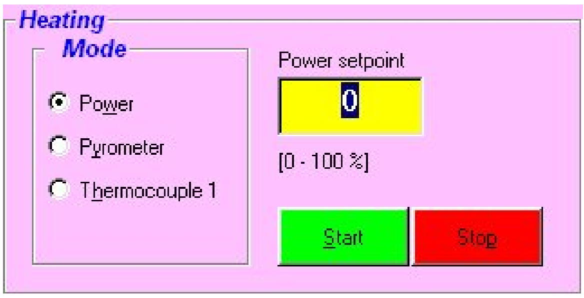
8.5.5. Manual heating

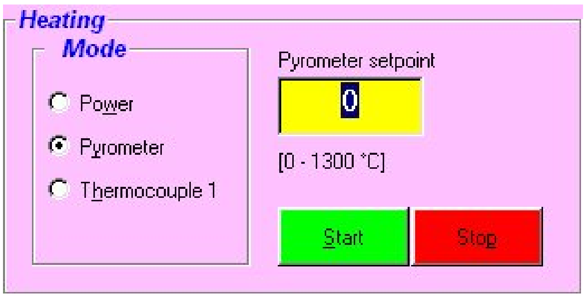
The **Manual Heating** mode allows powering the lamps using power, pyrometer or thermocouple TC1 heating mode. When **Manual Heating** mode is selected, cooling starts and the chamber has to be closed.

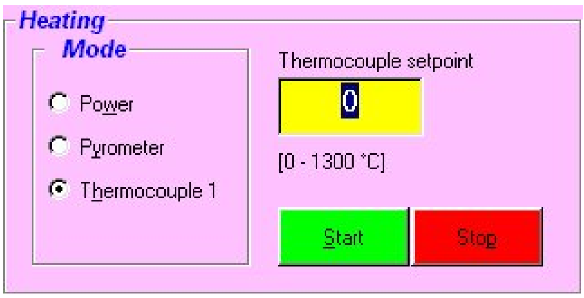


HEATING

You can choose between three different temperature regulation modes.







Procedure:

- Choose the **heating mode**: power, pyrometer or thermocouple control;
- Enter the temperature setpoint;
- Press the "**Start**" command and the heating starts immediately.

If you want to change the temperature setpoint, you do not need to stop the heating first. Just enter a new setpoint and press "**ENTER**" or click on "**Start**".

Clicking on "**Stop**" stops the heating and the temperature setpoint is set to zero.

CAUTION

At full power (100%) or even less, you can damage your substrate in a few seconds. The manual heating must be used only for adjustments and with low power. Some safeties are activated (water, overheating) and in case of water failure or thermocouple TC1 failure, the heating is automatically stopped.

COMPENSATION

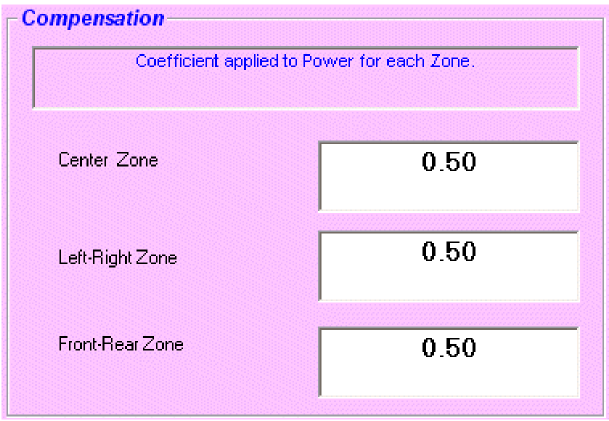
To improve uniformity, the third zone of lamps is perpendicular (or on the edge for JetFirst 200F) to the two first ones. This allows adjusting power on each zone with a compensation coefficient. The power is calculated by PID loop (RKC Module), apply to the center zone and this value can be increased or decreased on lateral zones. The power is just multiplied by the compensation coefficient.

*Example: Enter a temperature setpoint of 20% with t*he following parameters give as results:

INPUT PARAMETERS	OUTPUT EFFECTS
Center zone: 1 (with Power setpoint: 20%)	Center zone power = 20%
Front/Rear coefficient: 2.0	Front/rear zone power = 40%
Left/back coefficient: 0.5	Left/back zone power = 10%

Basically, compensation parameters need to be adjusted in 2 different situations: ramps and fix setpoints. So, for best adjustment, three compensation coefficients are added in recipe editor for each step.

For each zone (center, front/rear and left/right), this coefficient can be adjusted from 0 to 9.99 with a default value of 0.5 (50% of power).



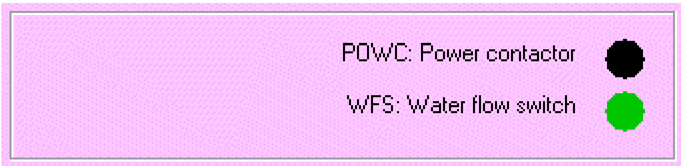
Compensation values need to be determined in manual heating mode.

READOUTS AND SENSORS

During manual heating, the screen displays the calibration table which is loaded in the controller and the following readouts:

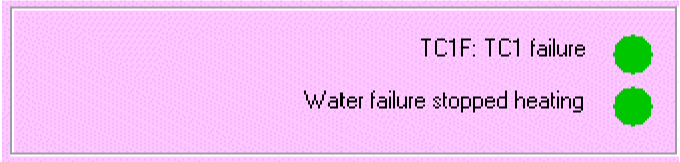
- Power (readout from system);
- Temperature from TC1, TC2 an dTC3;
- Temperature from pyrometer according to calibration table in °C and in V;
- Image of current for each heating zone and each current sensor (two per heating zone.

When heating starts the power contactor sensor switches to green and the water flow switch must be green:



According to the heating mode selected, when heating starts, the heating mode sensor switches to green:

If a failure occurs, thermocouple TC1 or water flow failure, the sensor switches to red and the heating is automatically stopped:



TOOLBAR

"**Temperature controller**" command button opens the temperature controller interface. See **section 8.8** for further details.

"**Purge flow on/off**" purge valve PUV allows to speed up the cooling of the reactor between two temperature setpoint if required.

"**Vacuum valve on/off**" vacuum valve ON start pumping inside the chamber.

"**Logic I/O**" displays the Inputs / Outputs table of the system (see **section 8.5.6**).

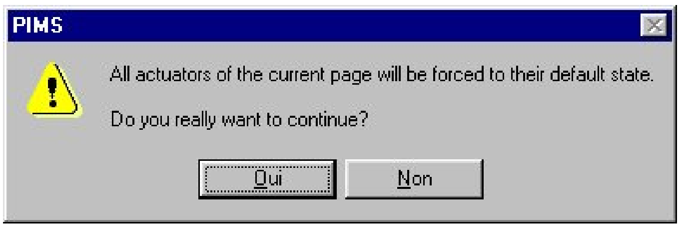
"**Exit**" will display the following message, run the cooling cycle and then return to the maintenance mode menu:

8.5.6. Inputs / Outputs

This option displays the inputs and outputs status of the programmable logical controller.

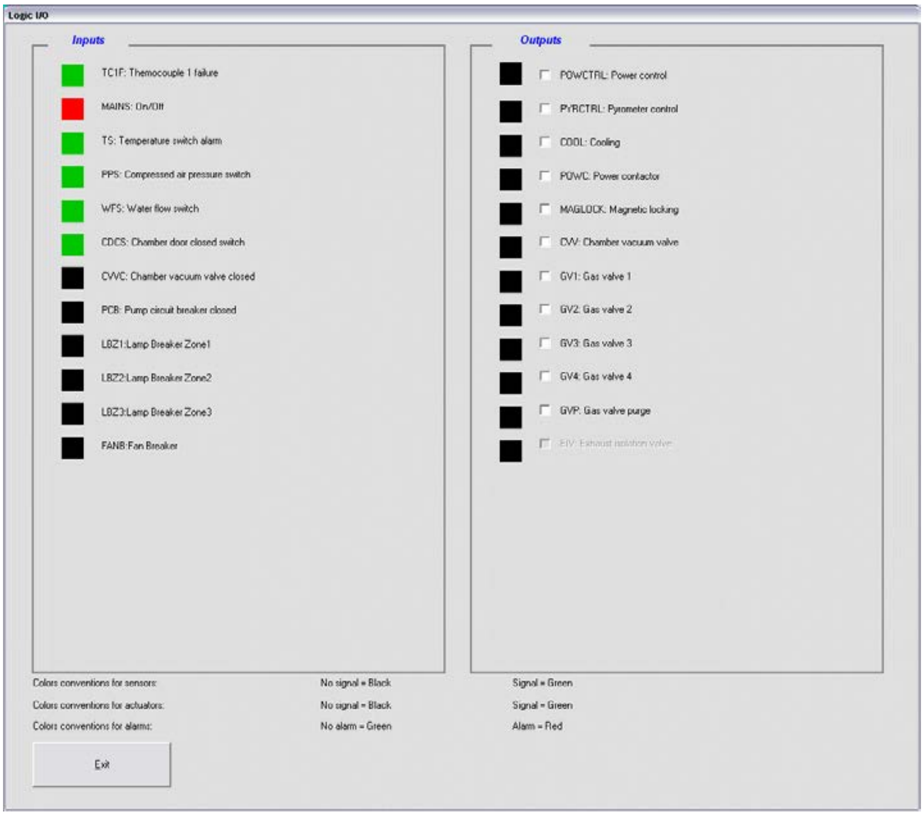
Note:

- The "**Output**" column includes checkboxes to commutate each output.
- From the **Maintenance mode**, and only from this mode, when you click on **EXIT**, a warning message pops up:

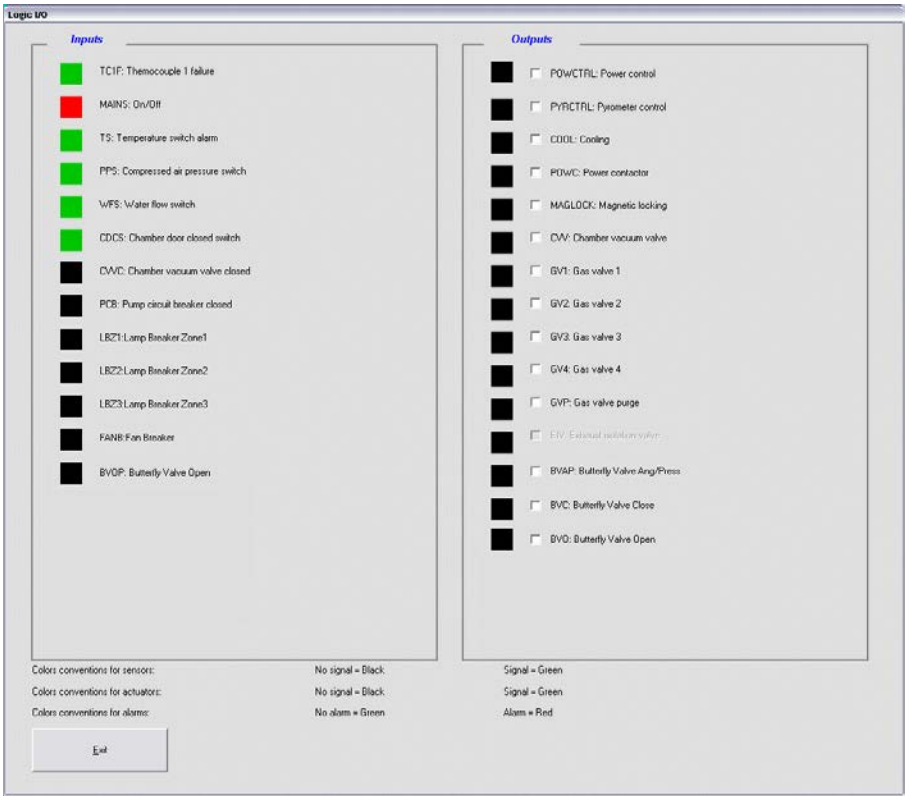


If the **Logic I/O** window is accessed from another mode, this warning message will not appear.

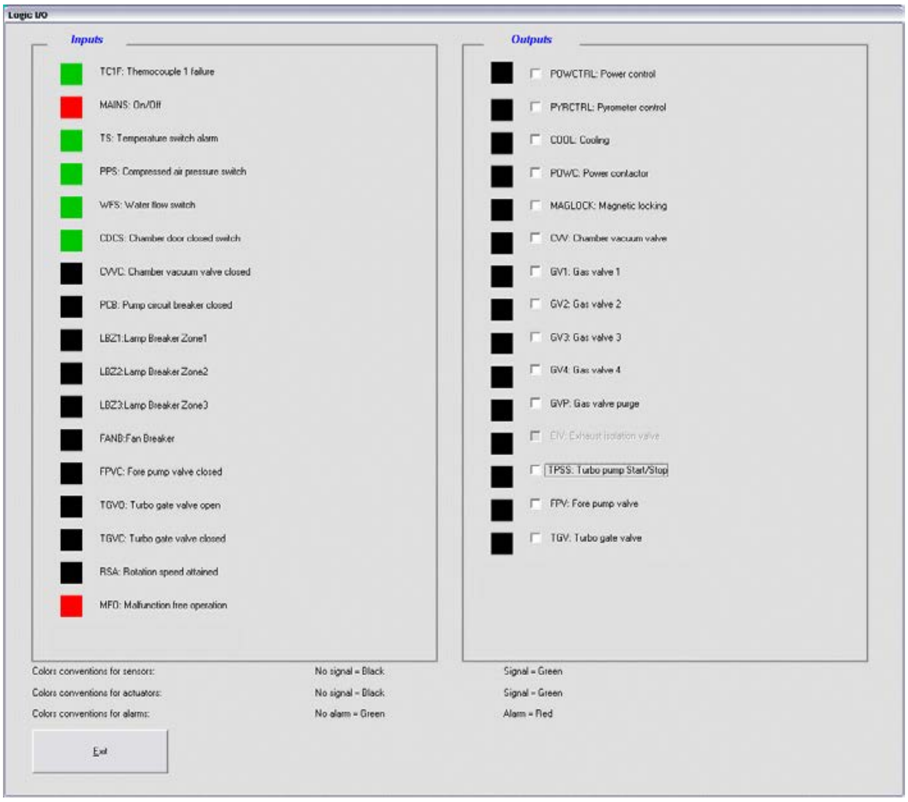
I/O WINDOW FOR STANDARD VACUUM CONFIGURATION



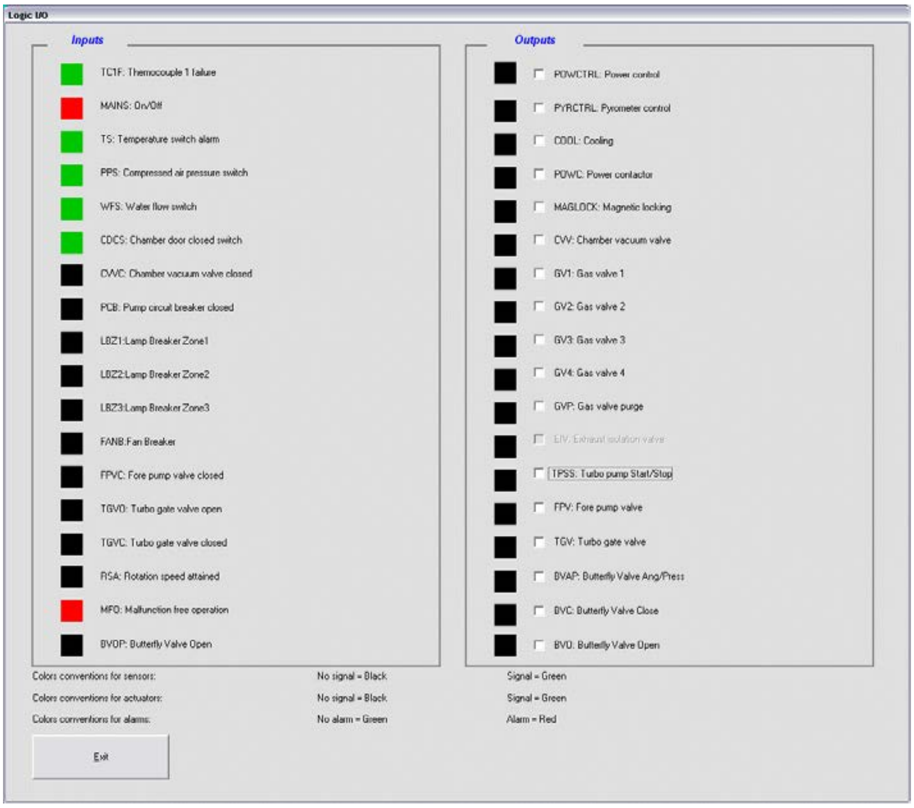
I/O WINDOW FOR VACUUM CIRCUIT WITH PRESSURE CONTROLLER



I/O WINDOW FOR VACUUM CIRCUIT WITH TURBOPUMPING UNIT



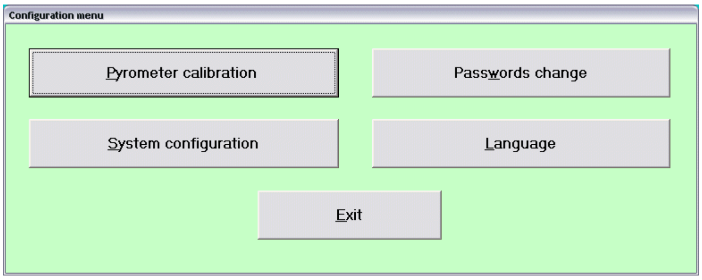
I/O WINDOW FOR VACUUM CIRCUIT WITH TURBOPUMPING UNIT AND PRESSURE CONTROLLER



8.6. CONFIGURATION MENU

The parameters menu allows entering in the system. The password must be entered to access to this mode.

When the **CONFIGURATION** mode is selected, the screen displays the following form:



CAUTION
Changing value of parameters may have important consequences on the behavior of the system. The operations must be carried out very carefully.

8.6.1. Pyrometer calibration

The temperature can be controlled either by the optical pyrometer or by a thermocouple. The calibration tables give the temperature from the sensor in relation to the voltage. For pyrometer, voltage is function of temperature and substrate’s emissivity. So the calibration curve depends on substrate materials and on layers on its surface.

The software allows entering several calibration tables that may be used to process substrates of different nature.

When the Pyrometer calibration mode is selected, the screen displays the Pyrometer calibration form:

Each calibration table is made of 30 temperature / voltage couples. The calibration curve will be made by interpolation between 2 couples of values. The operator has to enter 2 to 29 couples of values. The thermocouple is difficult to use up to 1000°C to record a calibration curve. The calibration curve is usually linear at high temperature and the computer will calculate the voltage value for 1200°C by prolongation of the last part of the curve that has been entered by the operator.

TO ENTER A NEW TABLE

Select "**New Table**" and enter a name (up to 10 characters).

You can enter a comment (optional).

If you use a low temperature pyrometer, you must select "**low temperature**" in order to have the right calculation for the max. temperature.

Then you have to enter temperature values for recording thermocouple and pyrometer signals at the same time. The thermocouple gives the wafer temperature for a voltage of the pyrometer. The operator must perform a multi-step process (50°C by 50°C for example) in thermocouple control mode in order to get the actual calibration parameters.

Each couple temperature/voltage must be entered in the calibration table so that the controller can make the right setpoint calculation.

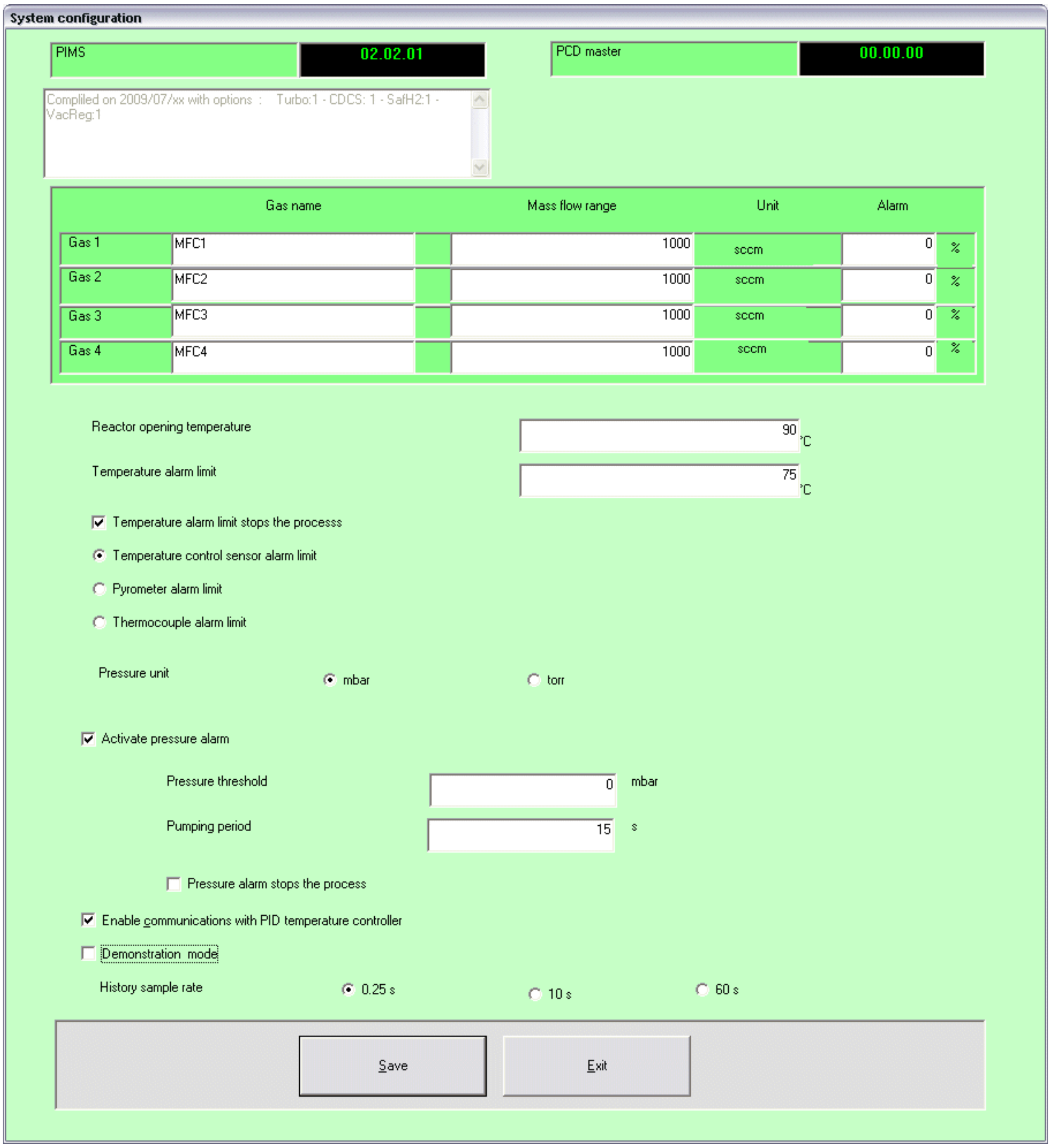
Go to **section 8.8.5** in this manual for further details on the calibration procedure.

OTHER FUNCTIONS AVAILABLE

- **Save as** To save a pyrometer table with a new name;
- **Delete** To delete a pyrometer table;
- **Print** To print the pyrometer table parameters on the color printer;
- **Exit** To return to the parameters menu.

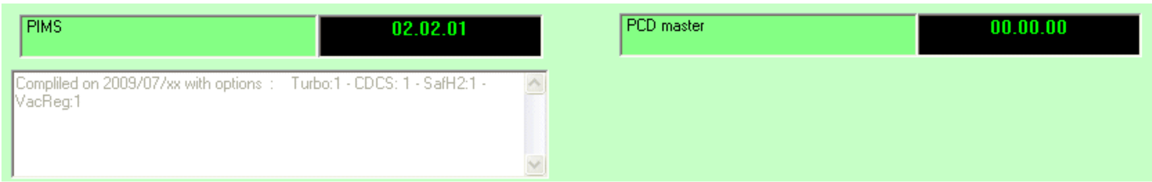
8.6.2. System Configuration

When the **CONFIGURATION** mode is selected, the screen displays the Configuration form.

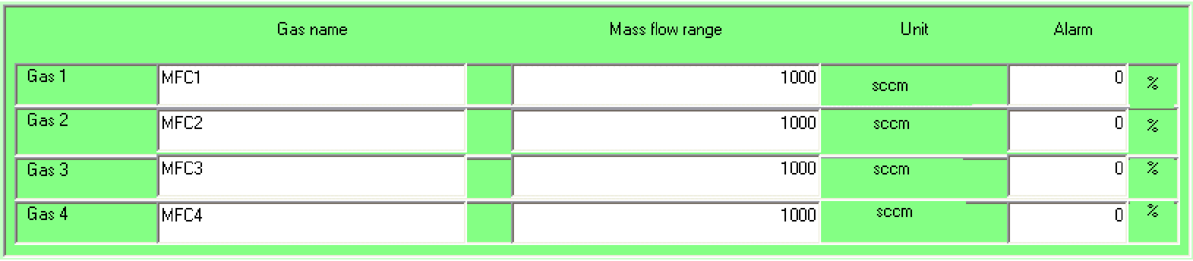


PIMS SOFTWARE IDENTIFICATION

The top part of this window gives information about PIMS and PCD version as well as system configuration options.



GASES



This mode allows entering the gas name and the mass flow range for each gas line.

It is also possible to select an alarm limit for each gas line in order to check during the process that the flow remains inside this limit. The gas flow alarm limit can be set from 0 to 20%.

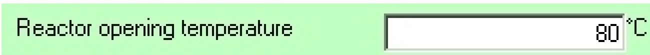
If the gas flow alarm limit is activated for a step and if the difference between the setpoint and the gas flow is over the alarm limit, the gas name will flash in yellow color. The gas flow alarm limit must be activated for each step.

IMPORTANT NOTICE

When the gas name is entered, the system will set the corresponding valve status indicator.

It is important to set one gas name for each gas line actually provided on the JETFIRST system.

OPENING TEMPERATURE

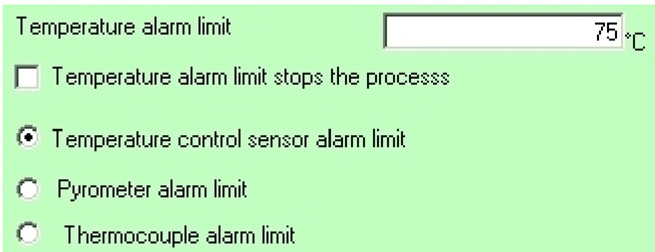


During the process, the chamber is locked for safety reasons (gas in the chamber, hot samples).

The chamber remains closed during cooling sequence until the temperature is over the opening temperature (90°C).

The default value for the opening temperature is 90°C. It can be set to any value between 0 and 999°C.

TEMPERATURE ALARM LIMIT



If the temperature alarm limit is activated for a step and if the difference between the setpoint and the temperature measured is over the temperature alarm limit, the system will display an alarm message. The temperature alarm limit must be activated for each step.

The configuration mode also allows configuring the software in order to stop the system if there is a temperature alarm limit.

The temperature alarm limit can be checked by 3 different methods:

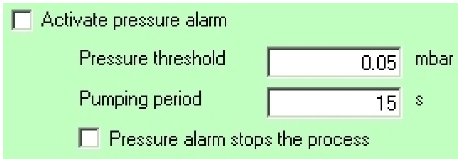
- *Temperature control sensor alarm limit*: The temperature sensor checks the temperature. If the system is on thermocouple control mode for the step the alarm limit will be checked with the thermocouple signal. If the system is on pyrometer control mode for the step the alarm limit will be checked with the pyrometer signal. If the temperature from the sensor is outside the limit and if the temperature alarm limit is activated for the step, the alarm limit will be activated.
- *Pyrometer alarm limit*: The pyrometer signal is used to check the temperature limit. If the temperature from the pyrometer is outside the limit and if the temperature alarm limit is activated for the step, the alarm limit will be activated.
- *Thermocouple alarm limit*: The thermocouple signal is used to check the temperature limit. If the temperature from the thermocouple is outside the limit and if the temperature alarm limit is activated for the step, the alarm limit will be activated.

It is possible to stop the process as soon as the temperature alarm limit occurs. Just select "**Temperature alarm limit stops process**".

PRESSURE UNIT

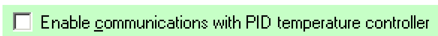
The operator can chose to display the pressure in Torr or mbar. Just select the right option in the configuration mode.

You can activate the pressure alarm. If pressure is reaching the pressure threshold, pumping starts for a defined duration.



It is possible to stop the process as soon as the pressure alarm is ON. Just select "**Pressure alarm stops process**".

COMMUNICATIONS WITH TEMPERATURE CONTROLLER



This checkbox allows setting on/off the communication between the RKC temperature controller and the PIMS control software.

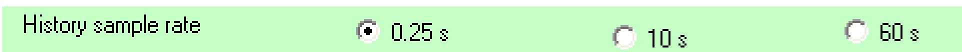
DEMONSTRATION MODE

This mode allows running the software without running the JetFirst system.

It can be used for operator training or to install the software or another computer to display process historical.

When the Demo mode is selected, a red bar message is displayed on the main menu screen.

HISTORY SAMPLE RATE



This field allows setting the sample rate dedicated to the historical graphic representation of process recipe curves. It is useful for long process sequences (several hours). As a standard, a curve is drawn with one point each 0.25s. With this option you can choose to set this rate from 0.25s up to 60s.

8.6.3. Language

This option allows changing language for PIMS control software:

- French;
- English.

When the Language mode is selected, the screen displays the Language form:

When the language is selected, the program is stopped and must be restarted.

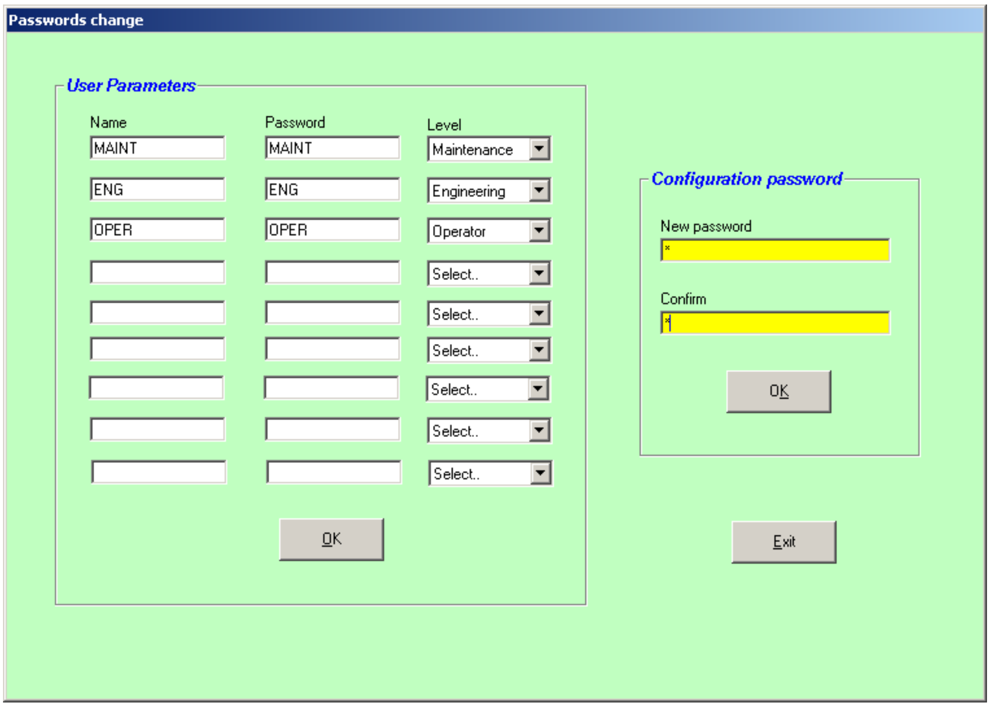
8.6.4. Change password

This option allows changing the password that is needed to access to **Recipe**, **Historical**, **Maintenance** and **Configuration** modes.

Access levels for modes:

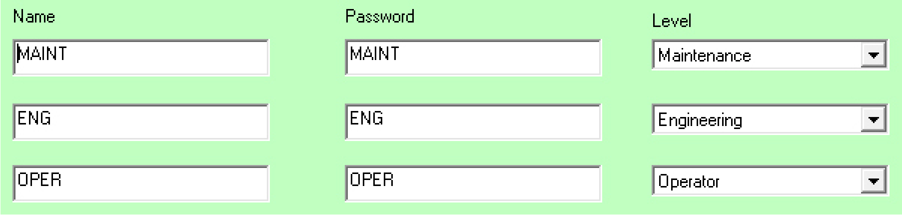
- *Historical* is accessible for all users without password;
- *Processing* requires the **OPERATOR** access level;
- *Recipes* requires the **ENGINEERING** access level;
- *Maintenance* and *Configuration* require the **MAINTENANCE** access level.

To access the password change dialog box, ones have to be logged in *maintenance* access level.



User parameters

Up to nine user profiles can be set. For each user profile, ones can choose between three different access levels. Default user profiles are listed here.

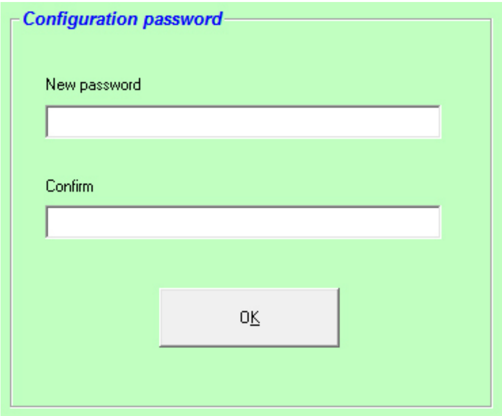


“Super” user

As logins and passwords are not encrypted in User Parameters field, a “super” user profile is implemented. Default login and password are:

- Login (respect lower / upper case letter): **ConfigUser**
- Password: **J**

The login name cannot be deleted neither changed. The password can be change using the Configuration Password field.

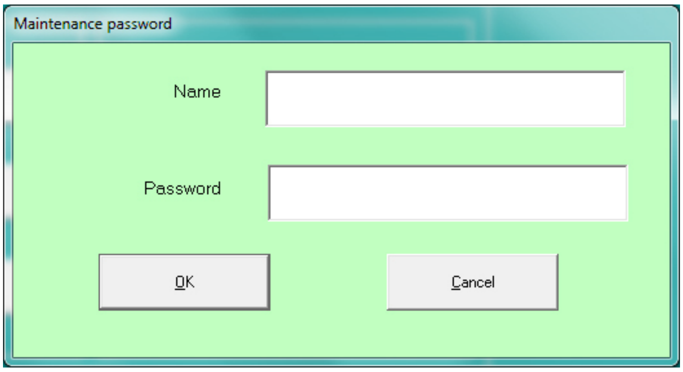


NOTICE

If all user profiles are deleted, ones will not be able to enter the Password Change dialog box. In this case, ones need to log in as the “super” user.

Logout

There is no “logout” function, ones only need to exit the control software to log off. If user does not have access to a mode, a dialog box appears asking for login and password in ordering to accessing a higher access level.



8.7. HISTORICAL MENU

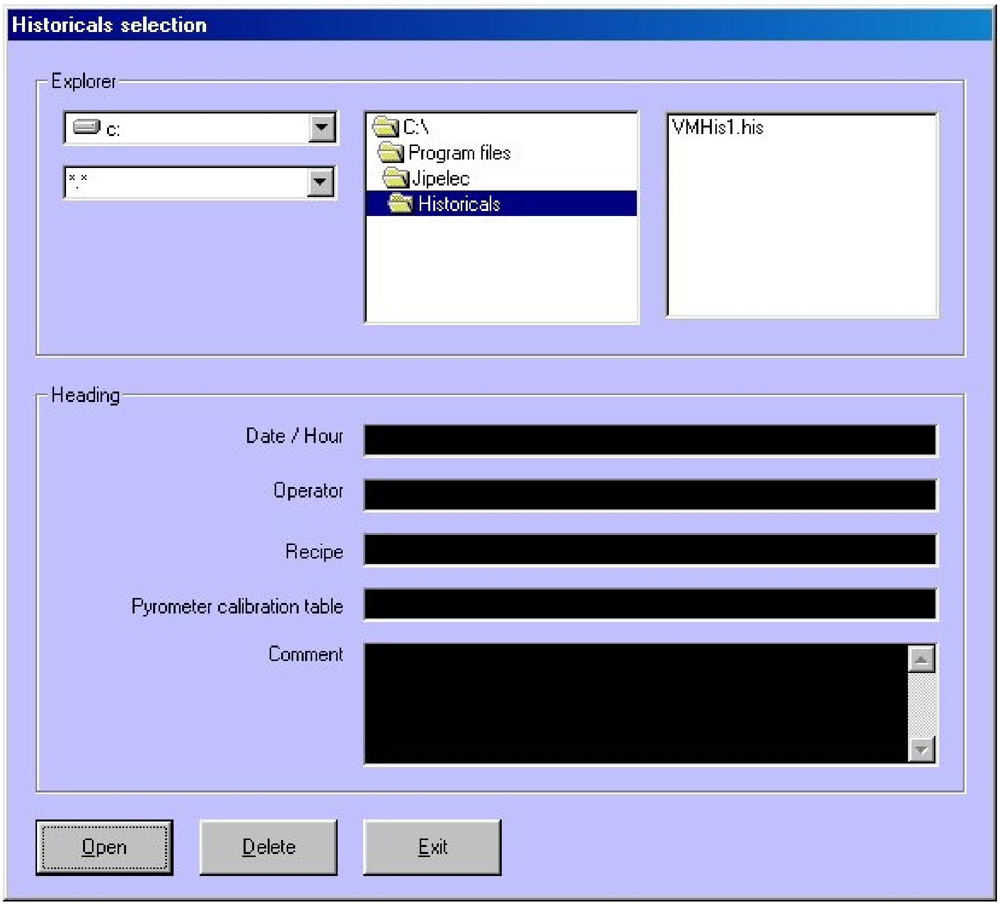
This mode allows:

- Displaying historical records of processes which have been saved;
- Displaying the list of alarm events.

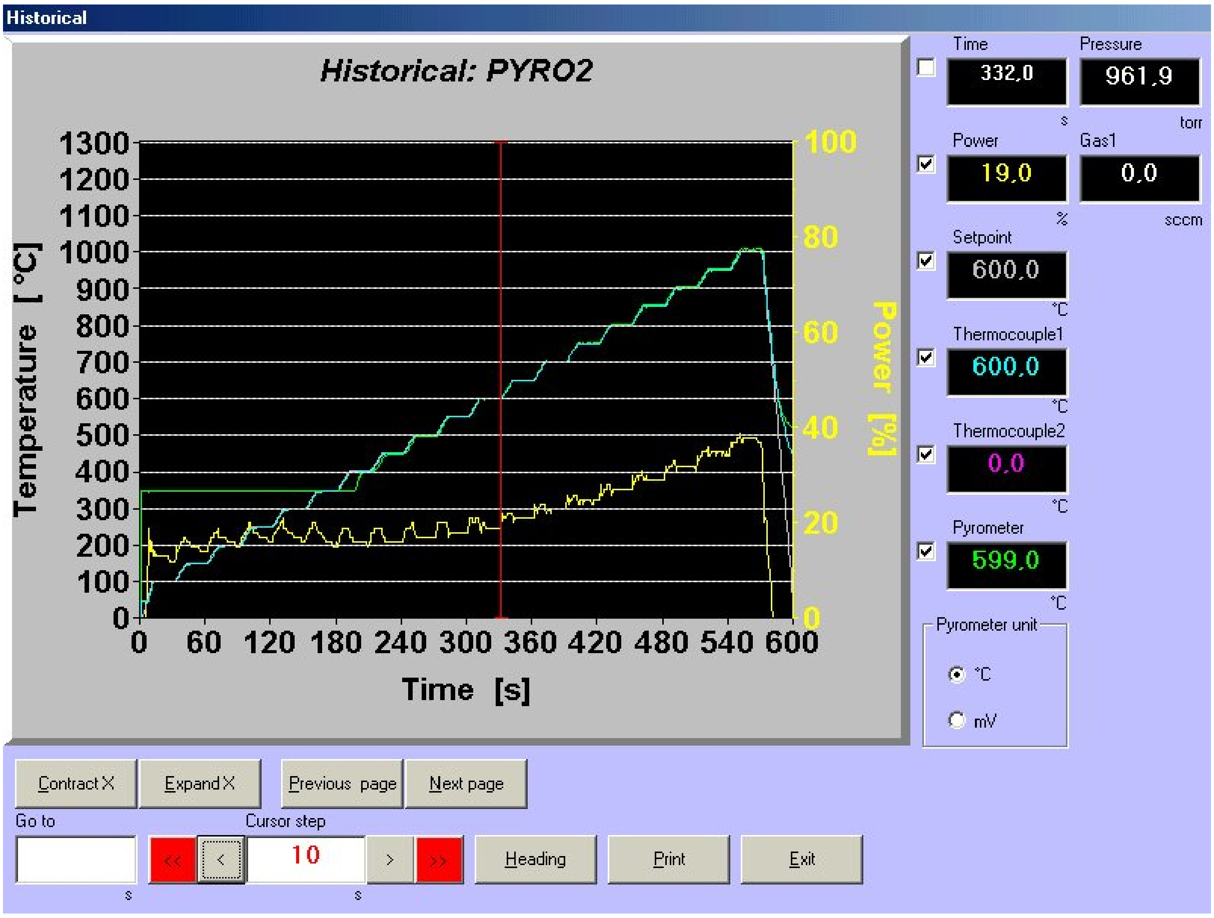
Select "**Historical**" and the screen will display a new form asking for "**Historical**" (Process records) or "**Alarms**" (alarm events). “**Exit**” will return to the main menu.

8.7.1. Historical selection

When this mode is selected, the system displays a screen allowing finding the record on the right disk drive and in the right directory. The default option is "**Historical**" directory on hard disk C.



Select the historical file to display in the list on the left side and then select "**Open**". The historical will be loaded in the computer memory.



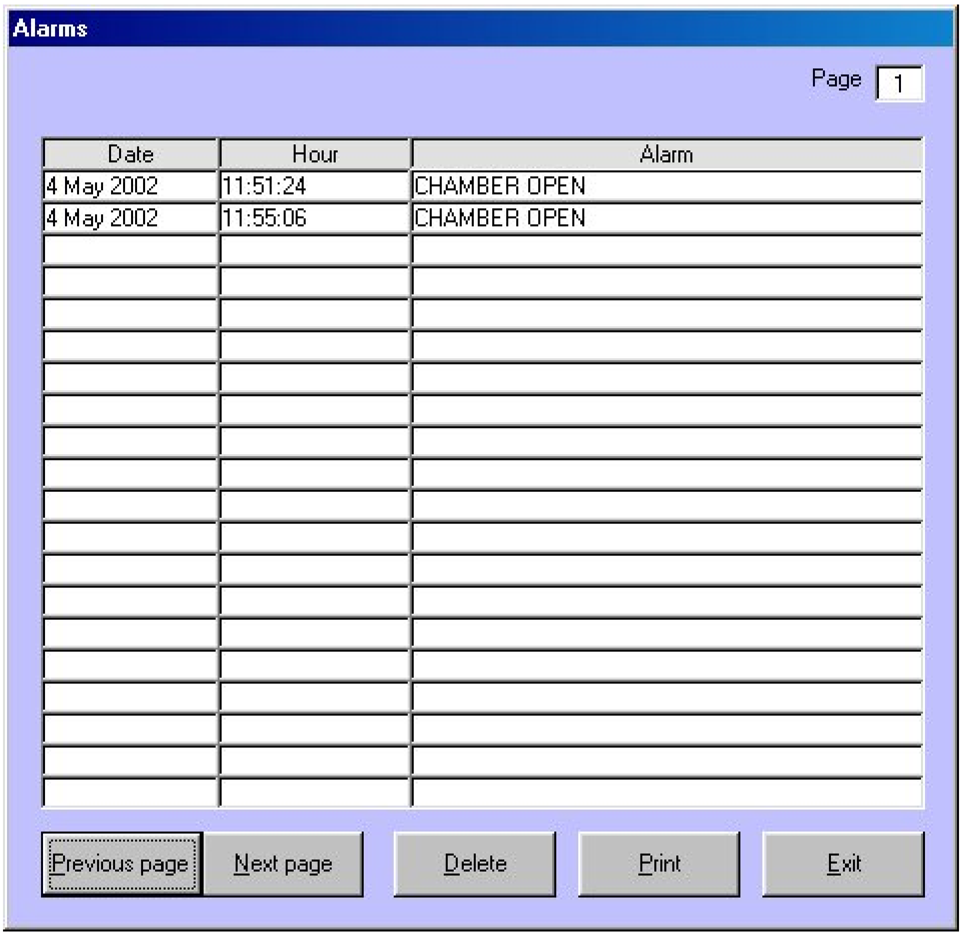
A toolbar under the historical screen provides the following features (from the left side to the right side):

Contract X	When historical is loaded, the screen will display the 3 first minutes of the recorded process. It is possible to use this key to increase the time scale of the historical;
Expand X	This option allows decreasing the time scale of the historical;
Print	To print the historical as displayed on the screen;
Previous page	To display the previous page of the historical;
Next page	To display the next page of the historical. A curve is available to display the values of the parameters at one instant value. The cursor can be moved using the following keys;
Backwards – big steps	Move the cursor backwards by the number of second displayed in the white box;
Backwards – small steps	Move the cursor backwards by 0.5 s steps;
Forwards – small steps	Move the cursor forwards by 0.5 s step;
Forwards – big steps	Move the cursor forwards by number of second displayed in the white box;
Pyrometer unit	To switch the pyrometer signal for °C to mV;
Show heating	To display the details of the historical (historical name, operator's name, recipe's name, pyrometer calibration table's name, comments);
Exit	To go back to the historical choice form.

The graphical window is fully **customizable**. You can enter your own parameters for scale ranges, text format, graph type, etc… To change those parameters, just **double-click** on the element with the **left mouse button**.

8.7.2. Alarms

The "**Alarms**" key in historical menu allows displaying the list of all alarm events that have appeared on the system. See **section CHAPTER 9** for full details on software alarms.



Use "**Delete**" key to reset the alarm event list.

Use "**Print**" key to print alarm events list.

"**Exit**" will return to historical menu.

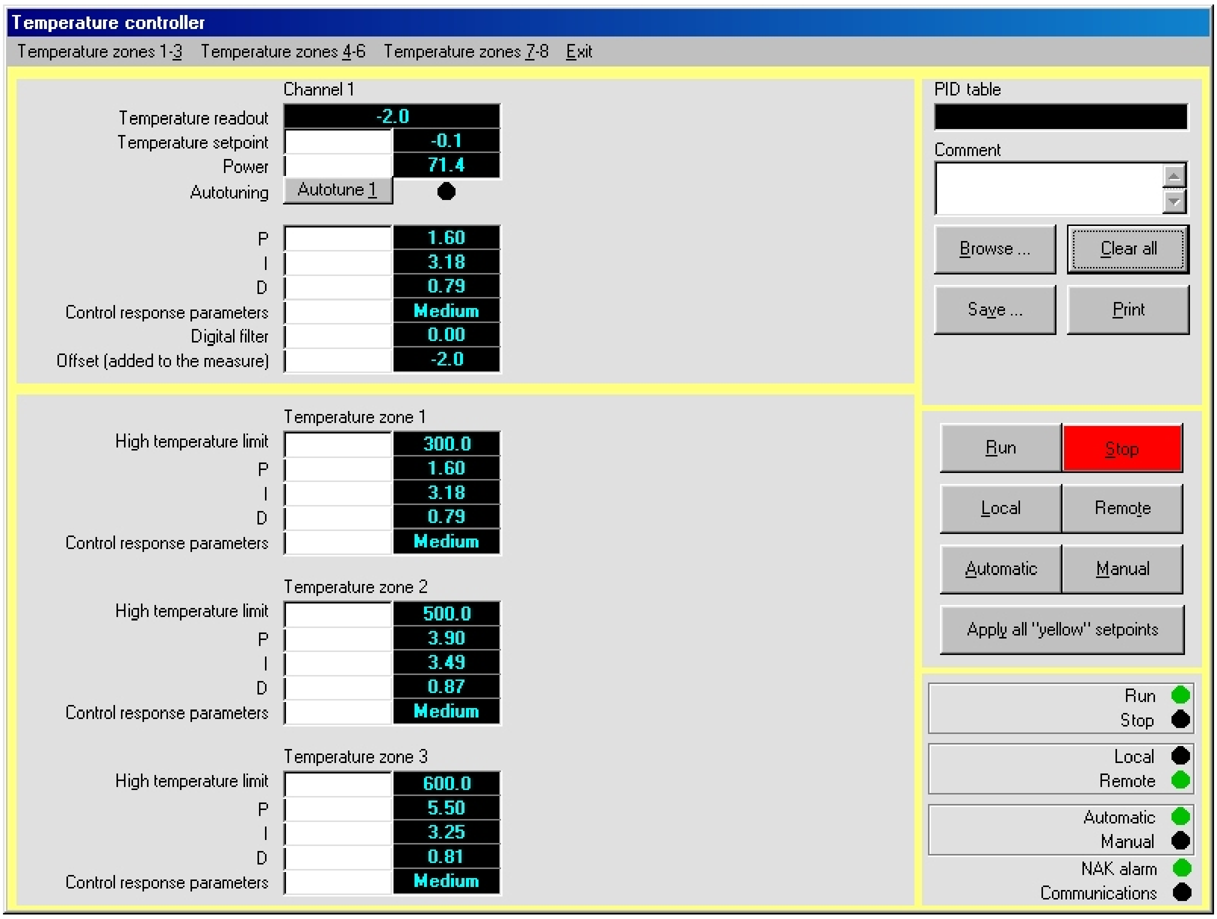
See **CHAPTER 9** for further details about safeties and troubleshooting.

8.8. TEMPERATURE CONTROLLER INTERFACE

8.8.1. Overview

The system is equipped with a temperature regulator. So the pyrometer calibration is performed by the RKC regulator. The calibration tables are saved on the computer hard disk as well as the PID tables from the RKC module. It is possible to save different tables for different substrate materials and to associate them to process recipes. The set of PID parameters have to be selected from temperature controller interface.

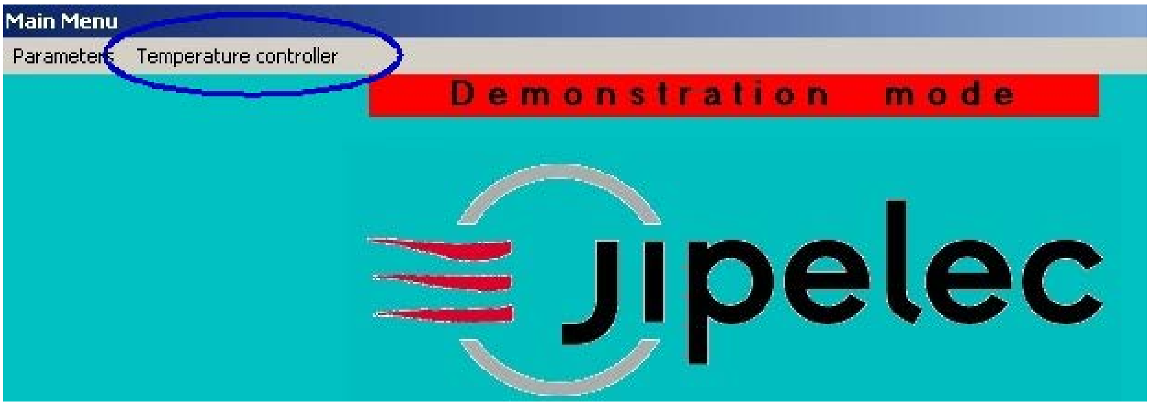
The following window allows setting all temperature regulation parameters through the PIMS control software of your system. Once all parameters are defined for your process recipes, this interface allows downloading the required PID table (as a file) for the recipe to be processed.



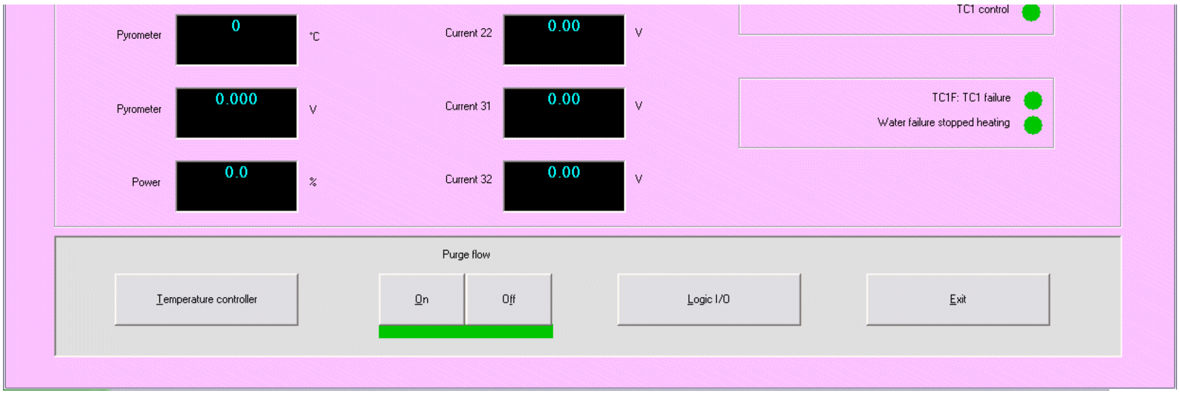
8.8.2. Accessing the Temperature Controller interface

The temperature controller window is accessible from different windows and sub-windows:

- From the main window;



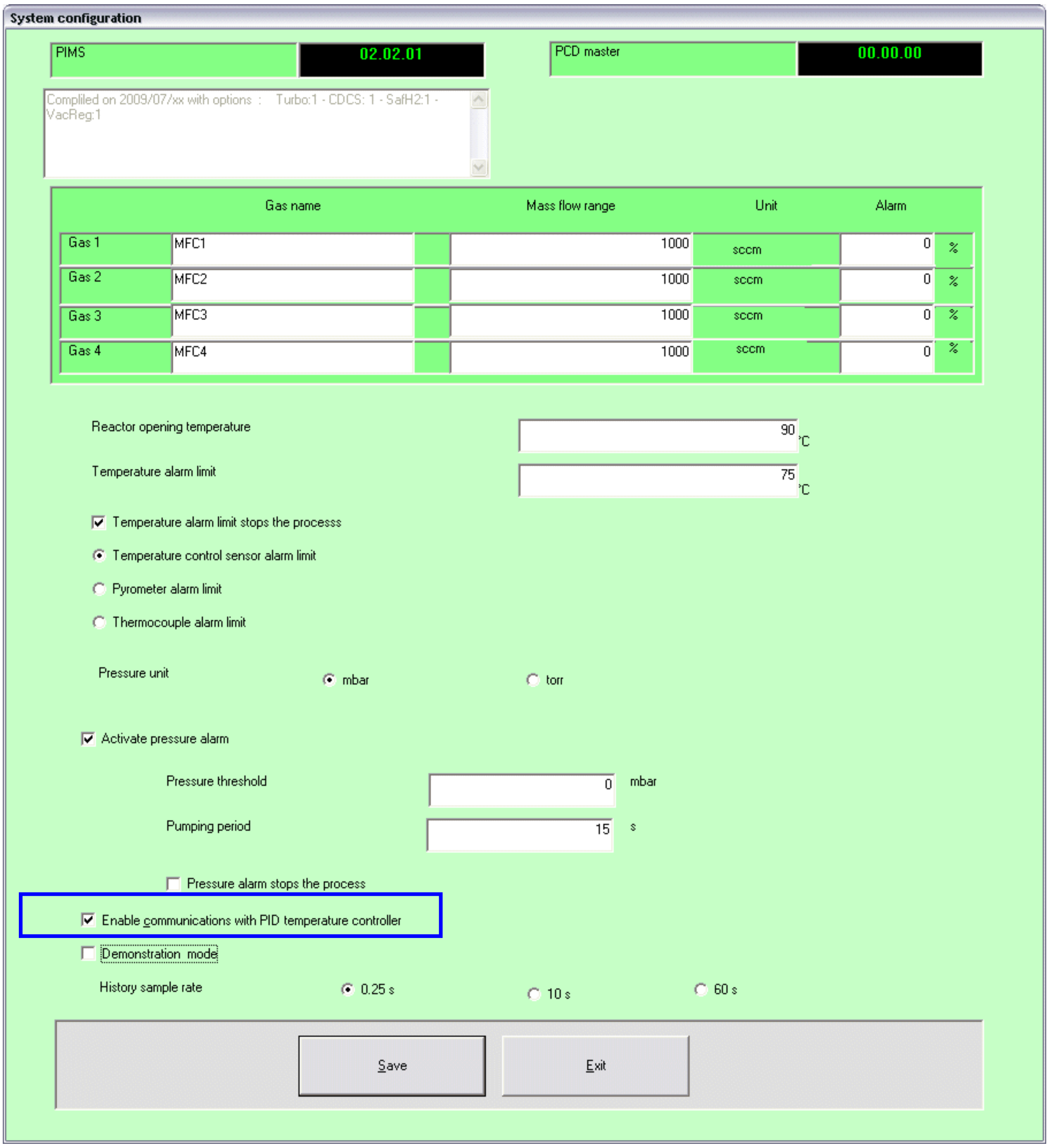
- From the Manual heating mode window;



8.8.3. Setting communication (ON or OFF)

SYSTEM CONFIGURATION

Two working modes are available for PID temperature regulator used in the PIMS control software. The working mode configuration is selected through the "**System configuration**" window of the PIMS (see **section 8.6** for further details).

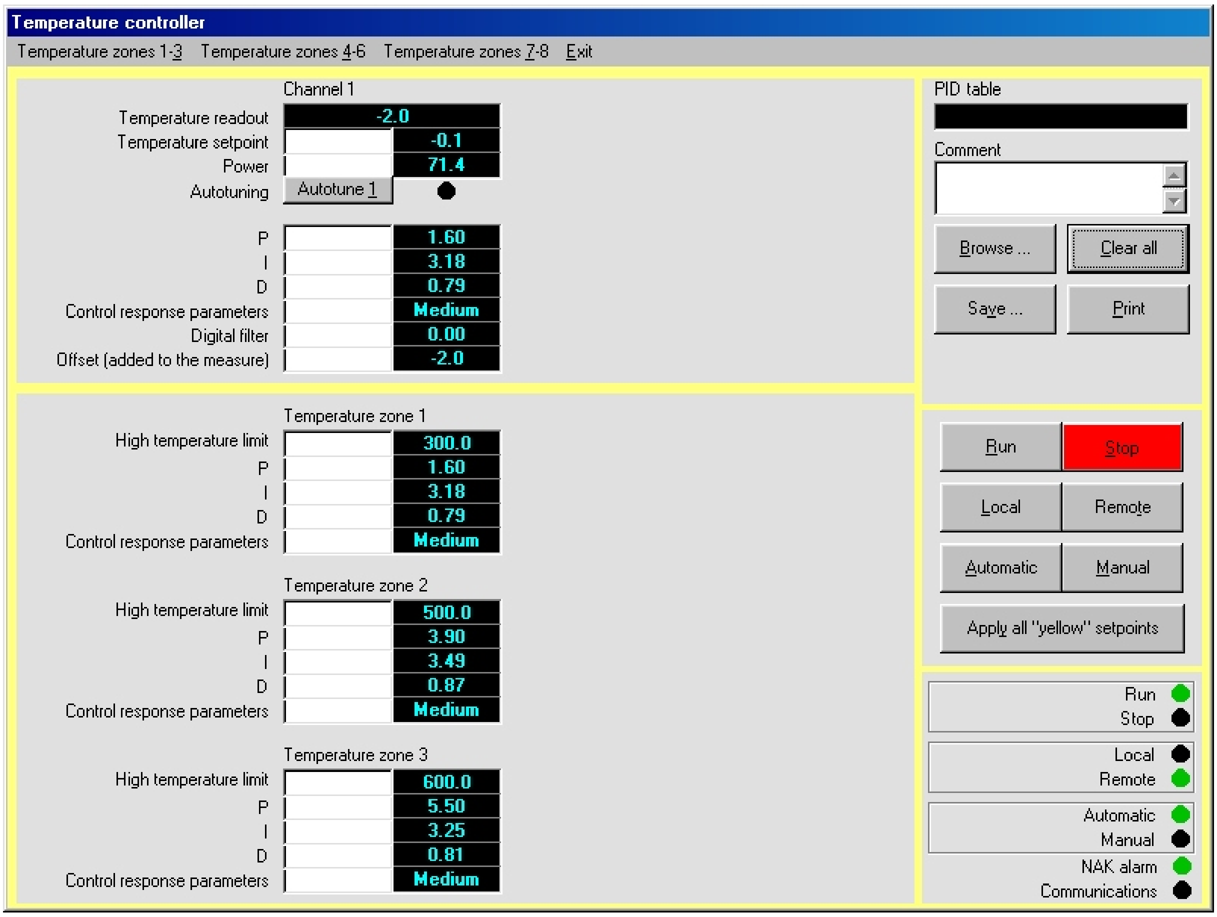


To set the communication ON, tick the required option as shown above. Do not exit the **System configuration** window without saving; otherwise your choice will not be validated.

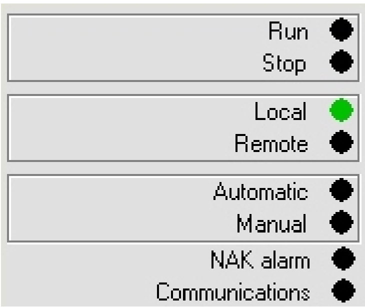
COMMUNICATION MODE ON

This mode gives access to the temperature controller window of the PIMS.

With this window, you can set all parameters of the PID temperature controller under real conditions (manual heating mode, processing mode …).



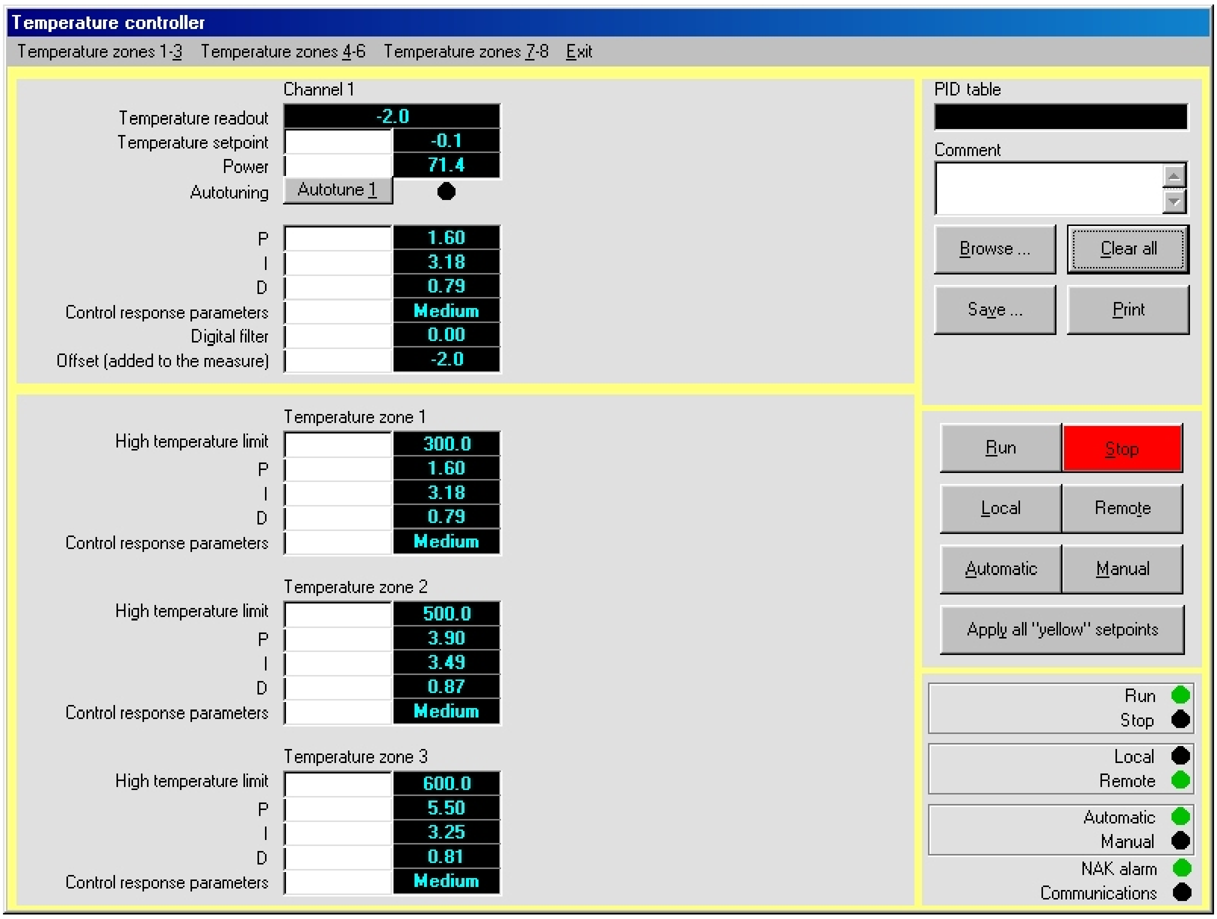
To check if the communication between the temperature regulator and the system is ON, check the "Communications" led at the bottom of the window. The led is blinking in green when communication is ON and keeps black when there is no communication.



8.8.4. Setting temperature regulation parameters

OVERVIEW

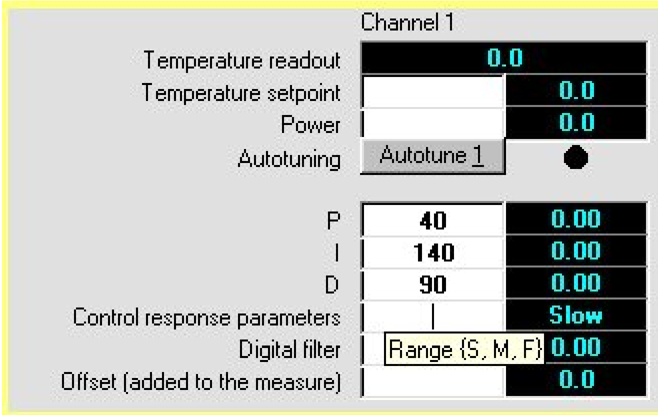
This interface, specific to the regulator installed on your system, allows setting up to 8 sets of PID parameters.



The main window allows entering PID parameters for **zone 1-3**. To access **zone 4–6** and **zone 7-8**, use the corresponding menu buttons in the menu bar, at the top of the window.

When entering parameters for the regulation of your system, you will use *Channel 1*.

Remember that the PIMS is using tool tip text. When you place the cursor in a text field, the value range appears.



ENTERING PARAMETERS

According to the recipe being processed, the set of PID parameters has to be adjusted properly. It means that once PID parameters are fully defined for each recipe, you just have to download the required PID table (as a file) and then run the recipe.

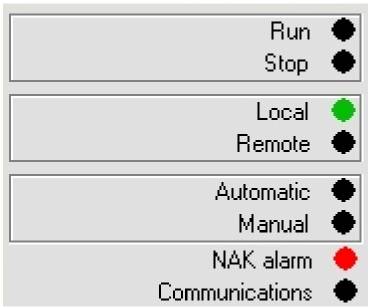
According to temperature regulation mode, **thermocouple** or **pyrometer** regulation, the temperature setpoint (High Temperature Limit value) entered is not entered in the same way:

- Thermocouple mode: the setpoint entered in the **Temperature setpoint** cell is a value expressed in Celsius degrees;
- Pyrometer mode: the setpoint entered in temperature readout, temperature setpoint and high temperature limit values are expressed in mVolt with a factor of 0.13. This value depends on the pyrometer calibration table used with your recipe.

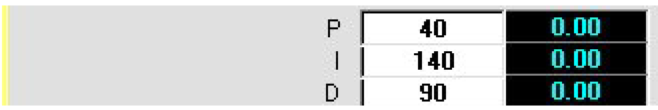
$$PyroValue = Voltage \times 0.13$$

Parameters to be defined:

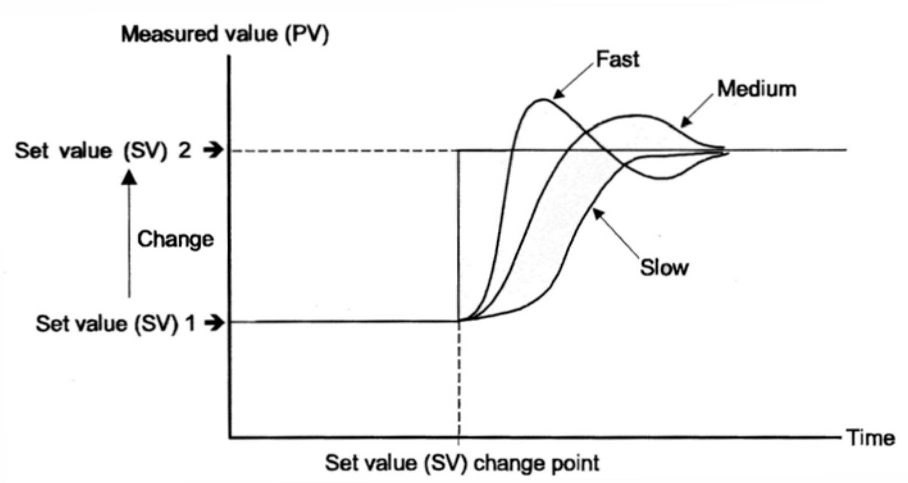
- **High temperature limit**: maximum 1300°C;
  The temperature value must increase, from zone 1 to zone 8.
  Notice: If for **zone *n*** you have $\mathbf{T_n < T_{n-1}}$, the value will not be accepted by the PIMS and the **NAK Alarm** will switch from **black** to **red**.



- **PID** parameters;



- **Control response parameter**: **S**low/**M**edium/**F**ast;
  The control response for the set value (SV) change can be selected among **Slow, Medium** and **Fast**. If a fast response is required, **Fast** is chosen. **Fast** may cause overshoot. If this is critical, choose **Slow**. Usually, we recommend using the **Medium** control response.



- **Digital filter**: time constant (0 – 10s) with a minimum step of 0.1s;
  This item is the time of the first-order lag to eliminate noise against the measured input. Filter is set to zero under thermocouple regulation. We advise to set the value to 0.75s under LT pyrometer regulation and 0.5s under HT pyrometer regulation.
- **Offset** (added to the readout): –100°C up to +100°C;
  Used to add a correction to the temperature input, defined under thermocouple regulation. A value of ±2°C is usually observed during the calibration of the system.

Offset = Readout – Setpoint = ±2°C

DOWNLOADING AND SAVING PID TABLES

The temperature controller interface allows to save the current regulation parameters in a file and to download an existing PID table.

Toolbar commands:

- To save a recipe, click on "**Save**" and enter the PID table filename. Select the destination folder and save the file;
- To open an existing PID table, click on "**Browse**" and select the folder containing the file to open. Once opened, parameters will appear on a yellow background until they are applied to the regulator using the "**Apply all yellow setpoints**" command button;

- Clicking "**Print**" will open the printer dialog box and print the regulation parameters;
- "**Clear all**" will erase all parameters entered in the temperature controller interface.

> NOTICE
> **Parameters can be applied individually by pressing the Enter key in each setpoint cell.**
> **When using "Apply all yellow setpoints" command button, check that values of black and white columns are the same. If not, re-enter the high temperature limit for each temperature zone (1 to 8) and press "Apply all yellow setpoints" command button again.**

DEFAULT PID TABLES

The system is provided with default PID tables for thermocouple and pyrometer regulation according to the substrate (Si, SiC with susceptor, SiC box) and to your applications.

Those tables are given for process at atmospheric pressure, without any gas circulation in the chamber. They are to be adjusted according to real processing conditions, especially processes under vacuum.

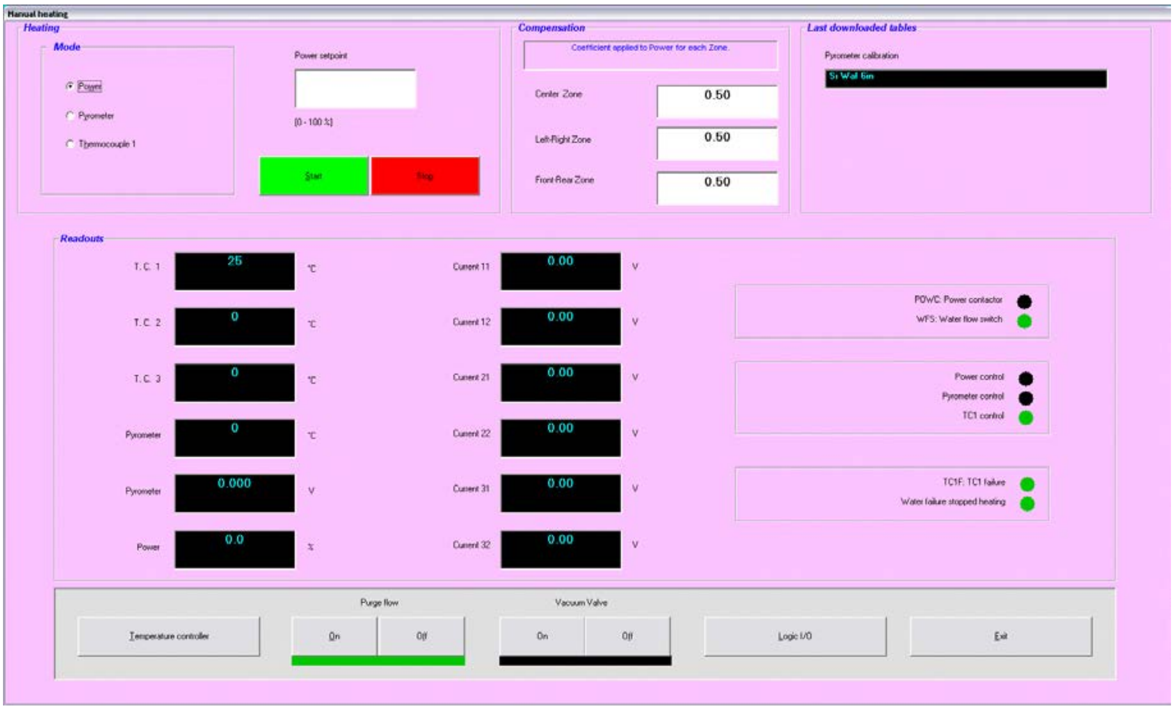
> NOTICE
> **The PID tables are specific to the temperature regulation mode used: thermocouple or pyrometer regulation. Do not use a PID table dedicated to thermocouple regulation if you are running under pyrometer regulation, and vice versa.**

8.8.5. Calibration & regulation procedure

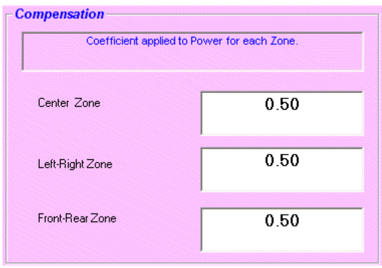
PID parameters can be defined by using the PIMS **Manual Heating** mode (see **section 8.5.5**). The procedure must be performed for both type of temperature regulation mode: **thermocouple** and **pyrometer**. The calibration procedure is defined into three steps. First regulation under thermocouple control, then definition of pyrometer calibration table, and finally regulation under pyrometer control.

Step 1 - Regulation under thermocouple control:

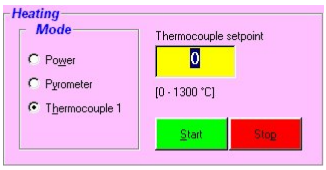
- Check that system is ready (water, compressed air, vacuum pump ON) and place a sample into the chamber and lock the reactor. Check that thermocouple TC1, located at center (except for susceptor; in this case, use K-type shielded thermocouple), is wired and in contact with the wafer;
- Open the MAINTENANCE – Manual heating dialog box;



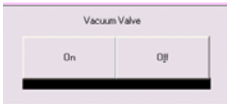
- Setup the temperature compensation coefficients. Typical values are 0.5 on each zone for process temperature around 500°C and 1 for process temperature above 500°C. See chapter 8.5.5 for details.



- Choose thermocouple for heating temperature regulation and enter 0 as setpoint. Press start to initialize the system and validate the system safety loop. This action is necessary to allow the temperature controller interface to take control over the system.

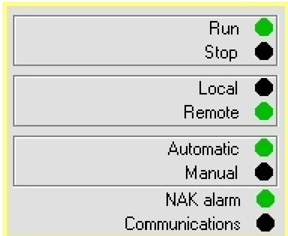


- If you want to perform regulation under vacuum, press "ON" in the toolbar to open the vacuum valve and wait for pumping;

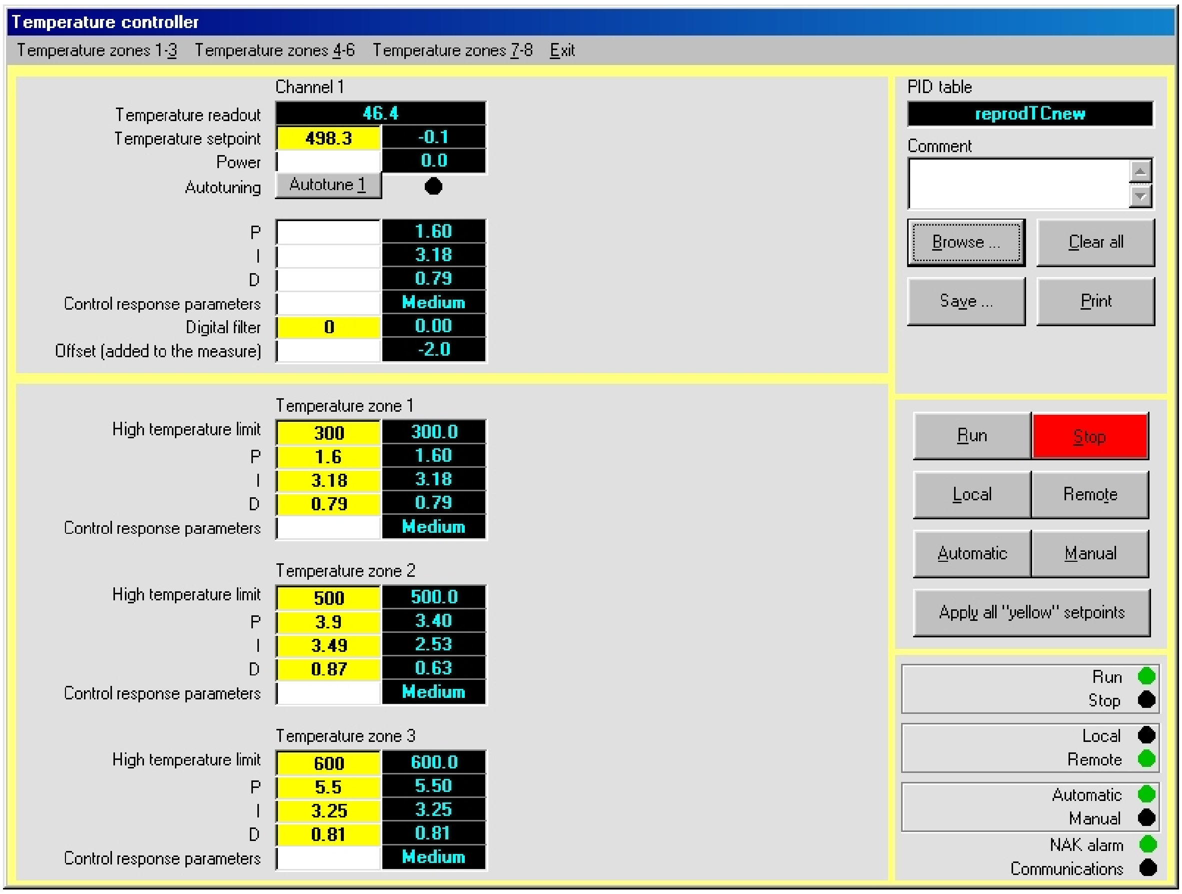


- Click on "Temperature controller" command button to open the interface of the temperature controller;

- In the temperature controller interface, check that RUN status light is green. If not, press the "RUN" command button;



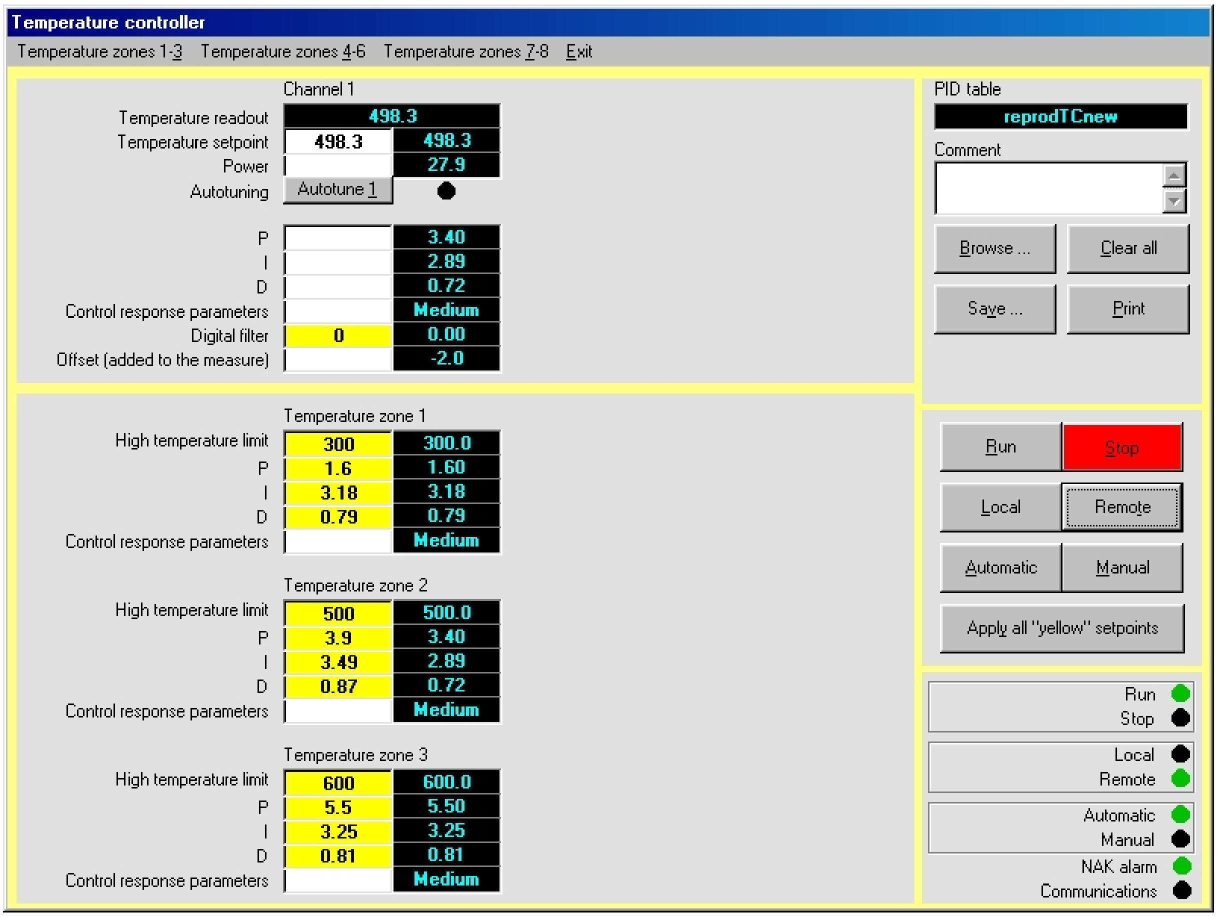
- Download an existing PID table (see **section 8.8.4**) or enter new set of PID parameters in the temperature controller interface.



- The system is provided with default PID tables for thermocouple and pyrometer regulation according to the substrate (Si, SiC with susceptor, SiC box) and to your applications. Those tables are given for process at atmospheric pressure, without any gas circulation in the chamber. They have to be adjusted according to real processing conditions, especially under vacuum.

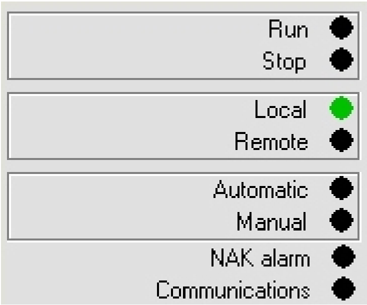
> NOTICE
> **PID tables are specific to the temperature regulation mode used: thermocouple or pyrometer regulation. Do not use a PID table dedicated to thermocouple regulation if you are running under pyrometer regulation, and vice versa.**

- Click on "**Apply all yellow setpoints**". This command sends all parameters to the temperature regulator. Check if parameters are well applied to the regulator, comparing the left and right columns of *Channel 1*. Check that values of black and white columns are the same. If not, re-enter the high temperature limit for each temperature zone (1 to 8) and press ENTER. If you recall the same table, click again on "Apply all yellow setpoints" command button again.

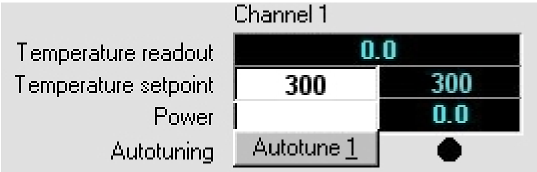


- Enter 0 as setpoint in the "Temperature setpoint" field and press ENTER;
- Switch to **Local mode** in the temperature controller interface in order to run the **Autotuning** on the regulator;

- When you select **Local**, the respective communication signal switches to green;

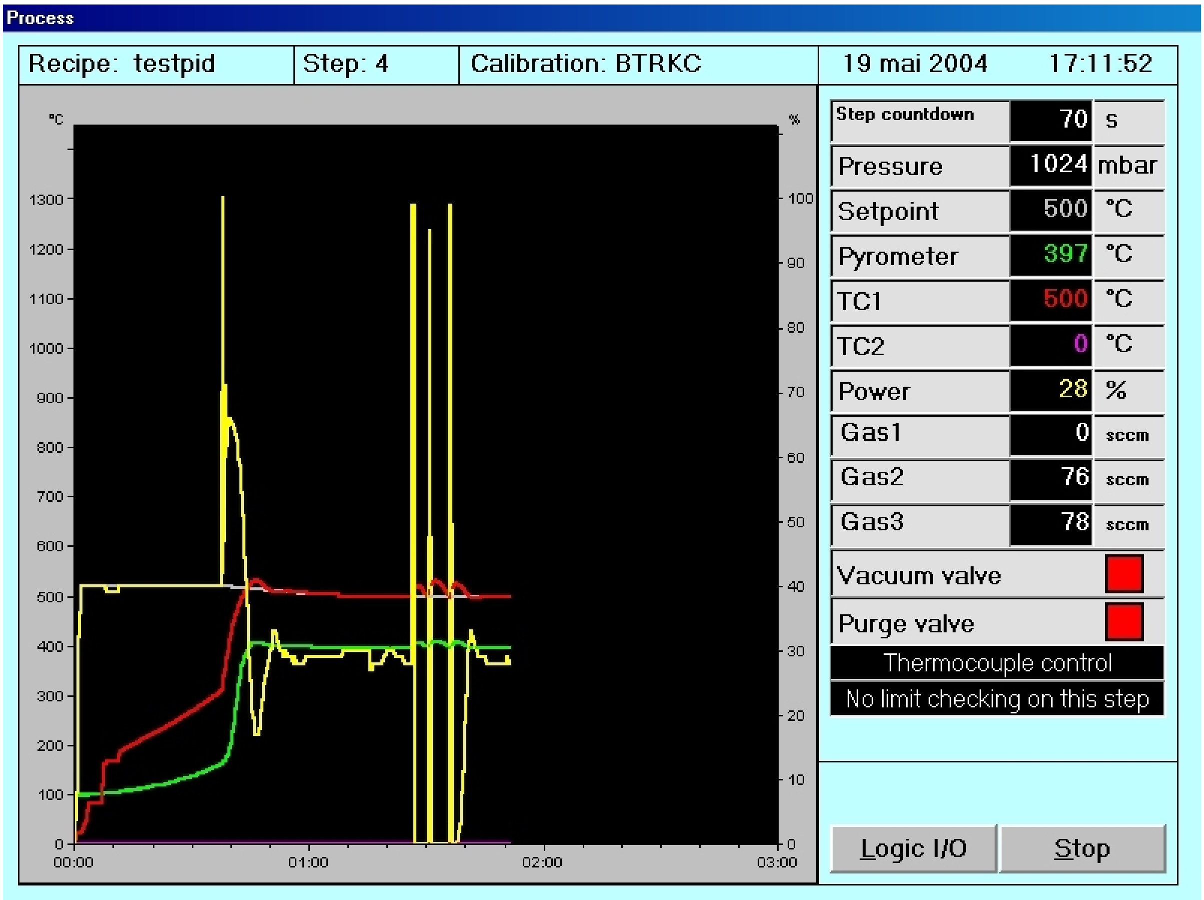


- Enter temperature setpoint with **step of 50°C** to increase temperature of the furnace up to 300°C before starting autotuning;
- **Enter** the temperature setpoint for **autotuning.** Click on **AUTOTUNE 1 once**;

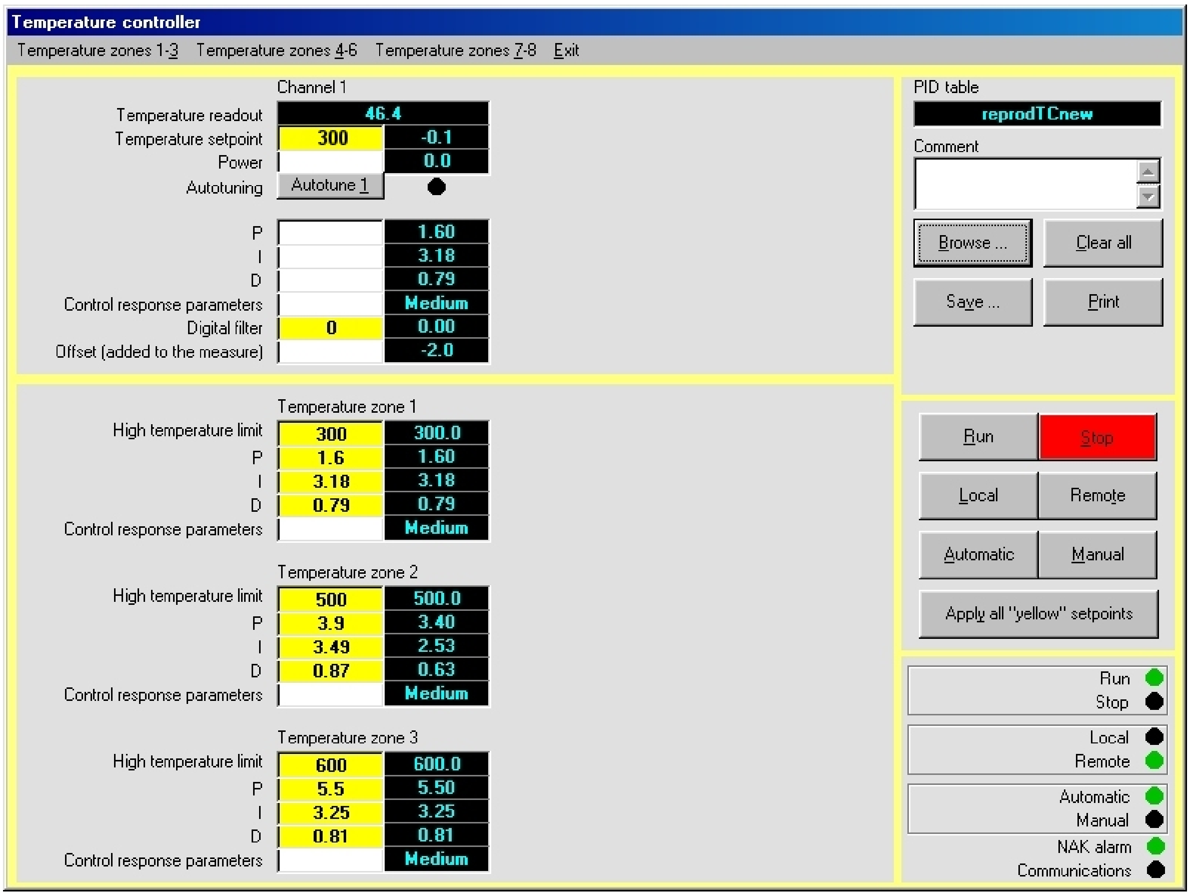


- During autotuning, the communication signal switches to **green** till the end of the autotuning sequence.

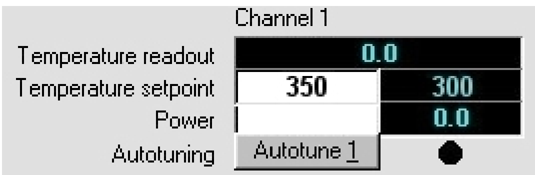
NOTICE
This sequence sets the power setpoint from 0% to 100% three times. After the first pick, the system waits that the readout gets back to the setpoint value to perform the second pick of power. Same behavior is repeated three times. This recovering time depends on setpoint value, process conditions and substrate material.
DO NOT ACT ON THE SYSTEM DURING AUTOTUNING SEQUENCE.



- Once autotuning is done, PID parameters are automatically stored in the black cells in the corresponding *Temperature zone* part of the temperature controller interface. For example, the temperature setpoint 300, as shown below, appears on zone 1;



- Write down on a sheet of paper the PID parameters of the autotuned temperature zone 'x' (with x = 1 to 8);
- To ease the calculation and stabilization of next temperature setpoint autotuning, enter in temperature zone 'x+1' the PID parameters of temperature zone 'x'. Click on "**Apply all yellow setpoints**" to send the PID parameters to the temperature controller. Enter the next temperature setpoint



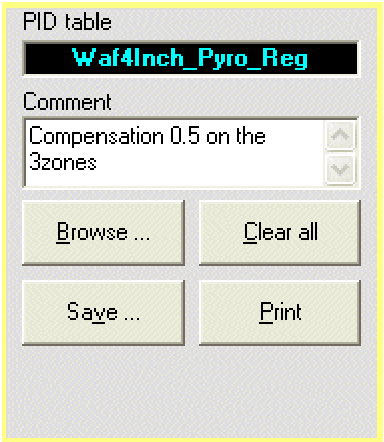
- **Repeat** the autotuning sequence for **each temperature zone (1 to 8)**. Repeat sequence for temperature setpoints from 300°C up to 1000°C (eight steps of 100°C for eight PID sets);

NOTICE

If calibration is performed under vacuum, last setpoint must be 850°C as thermocouple could be damaged at higher temperature.

- Switch to **Remote mode** to quit the autotuning mode;

- Once all sets of PID parameters are defined, open a **PID table** and **save it as** a new name, using an explicit filename (substrate, temperature regulation).

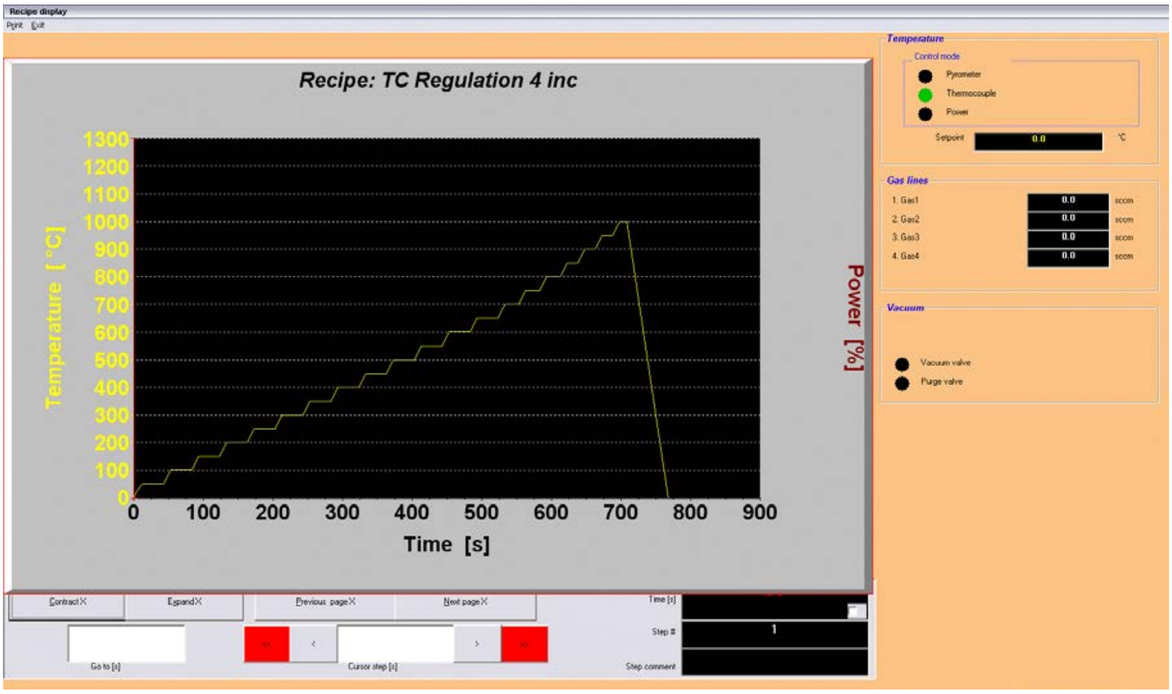


- Then **retype each PID parameters** (the ones written on the sheet of paper) for each temperature zone, respecting the increasing temperature limit rate.
- Finally save the PID table.

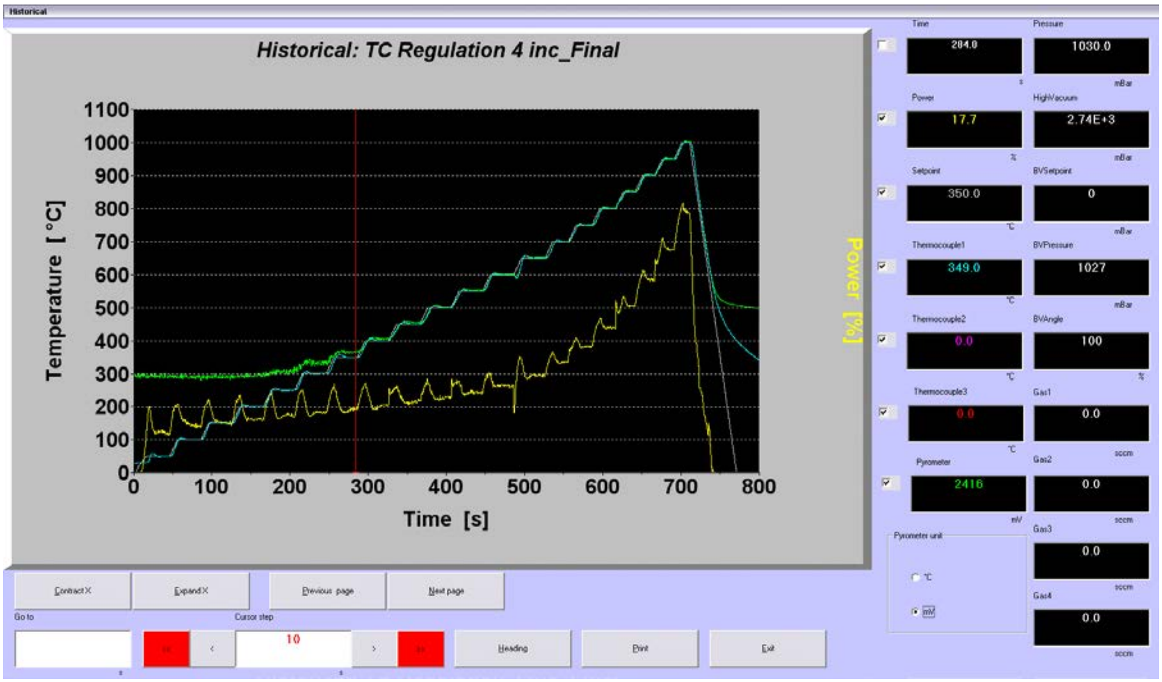
IMPORTANT NOTICE
Do not forget to save the PID table once the autotuning has ended and check that you are in REMOTE mode before closing the temperature controller interface window.

Step 2 – Definition of pyrometer calibration table:

- Check that system is ready (water, compressed air, vacuum pump ON) and place a sample into the chamber and lock the reactor. Check that thermocouple TC1, located at center, is wired and in contact with the wafer;
- Open the temperature controller interface and check that the PID table in memory is dedicated to thermocouple regulation;
- Run the standard recipe under thermocouple control called **TC Regulation 'x' inc.REC**. ('x' stands for wafer size). Recipe name might be different if you use susceptor. This recipe is set with steps of 50°C from 0° up to 1000°C;



- Once recipe has ended, go to Historical and open the historical file of the processed recipe;



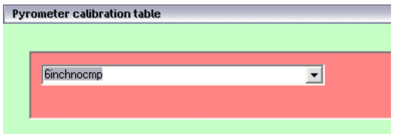
- Check the historical graph and note down on a paper sheet values of pyrometer in mV for each temperature setpoint, starting from around 250°C. At this temperature, you can see that pyrometer readout is starting to meet the thermocouple readout. Use the cursor to reveal values and place it at the end of dwell time (end of 30s step).
  Example: On the above historical graph, for a setpoint of 350°C, thermocouple readout value is 349°C and pyrometer readout value is 2416 mV.
- As the thermocouple doesn't measure temperature above 1000°C, you have to do an extrapolation of the temperature curve for setpoint values up to 1300°C;
  Example with the above process historical:

Temperature setpoint value (°C)	Voltage value type	Voltage (mV)	Extrapolation (mV)
950	Readout value	**5352**	0
1000	Readout value	**5511**	+159
1050	Extrapolated value	**5670**	+159
1100	Extrapolated value	**5829**	+159
1150	Extrapolated value	**5988**	+159
1200	Extrapolated value	**6147**	+159
1250	Extrapolated value	**6306**	+159
1300	Extrapolated value	**6465**	+159

- Once all voltage values noted down go to CONFIGURATION – PYROMETER CALIBRATION and create a new pyrometer calibration table. Save it with an explicit name (wafer or susceptor, size). Enter each couple of value (temperature, mV) from 250°C up to 1300°C;
- Run again the same process and check on the historical curves that thermocouple readouts and pyrometer readouts are as close as possible. If curves do not match each others, note down again pyrometer voltage values for each temperature setpoint. Repeat sequence two or three times if necessary;

Step 3 – Regulation under pyrometer control:

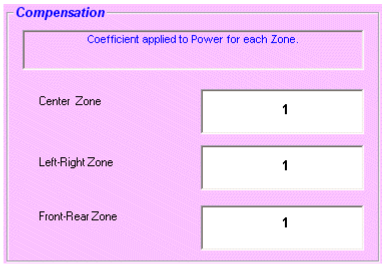
- Remove the left metallic panel of the system to access the thermocouple fittings. Pull down the thermocouples as pyrometer regulation is performed at temperature up to 1100°C and could damage the thermocouples. Ones just need to pull down the thermocouple to place the extremity of the thermocouple inside the lower reactor flange;
- Check that system is ready (water, compressed air, vacuum pump ON) and place a sample into the chamber and lock the reactor;
- Go to CONFIGURATION – PYROMETER CALIBRATION and open the pyrometer calibration table saved in step 2 of the calibration procedure from the scroll down list, according to the substrate (Si, SiC with susceptor, SiC box) and to your applications (atmospheric, under vacuum).



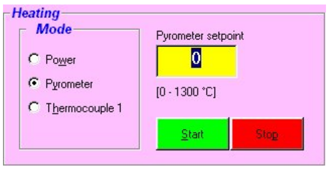
- Print or note down values of pyrometer (in mV) from 300°C up to 1300°C. Once printed, create a third column and apply a factor of 0.13 to each mV value;

$$PyroValue = Voltage \times 0.13$$

- Open the MAINTENANCE – MANUAL HEATING dialog box;
- Setup the temperature compensation coefficients. Typical values are 1 for process temperature above 500°C. See chapter 8.5.5 for details.

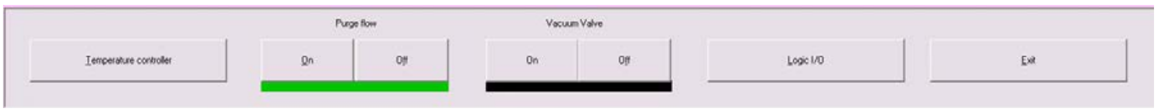


- Choose pyrometer for heating temperature regulation and enter 0 as setpoint. Press start to initialize the system and validate the system safety loop. This action is necessary to allow the temperature controller interface to take control over the system.

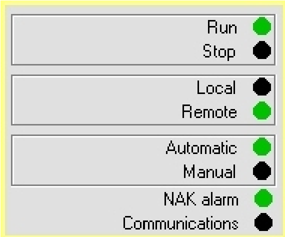


- If you want to perform calibration under vacuum, press "ON" in the toolbar to open the vacuum valve and wait for pumping;

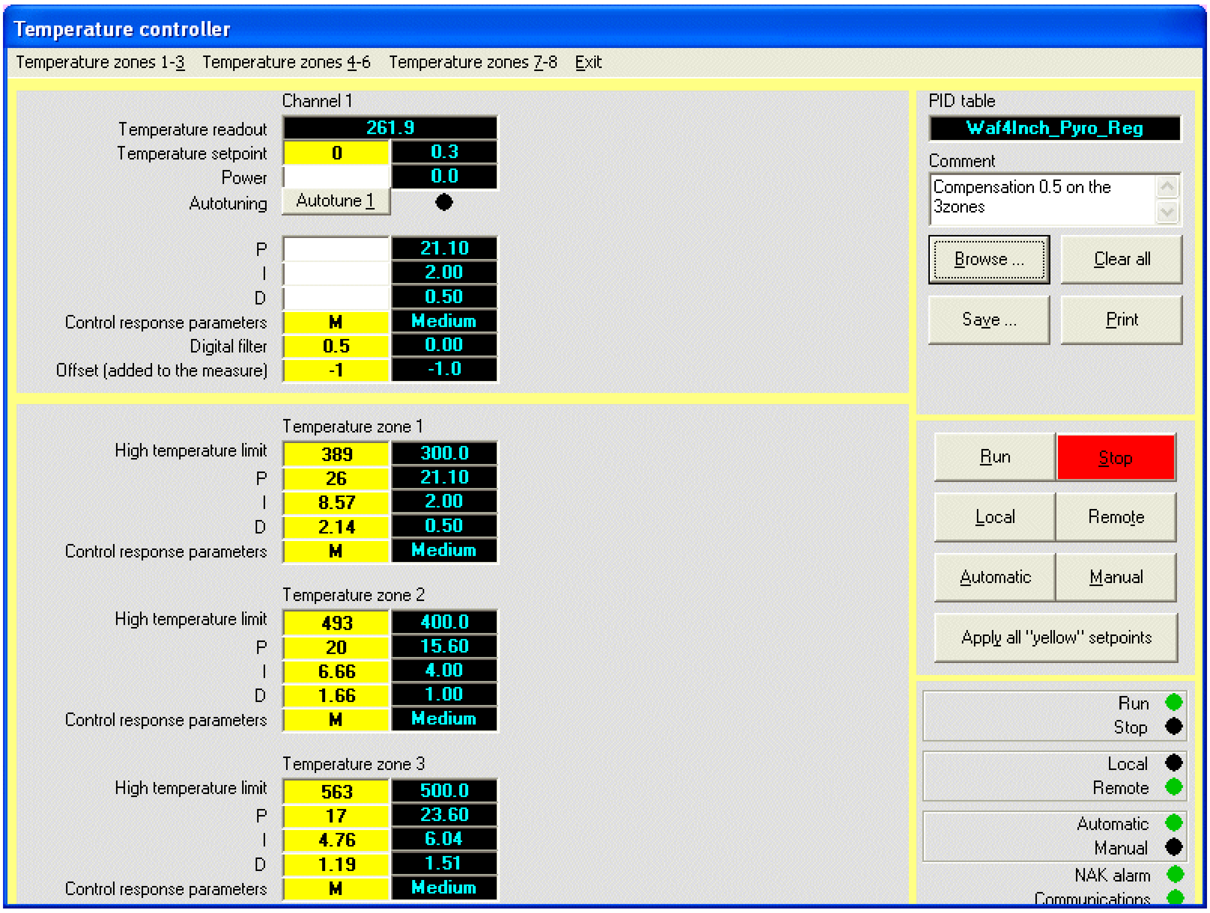
- Click on "Temperature controller" command button to open the interface of the temperature controller;



- In the temperature controller interface, check that RUN status light is green. If not, press the "RUN" command button;



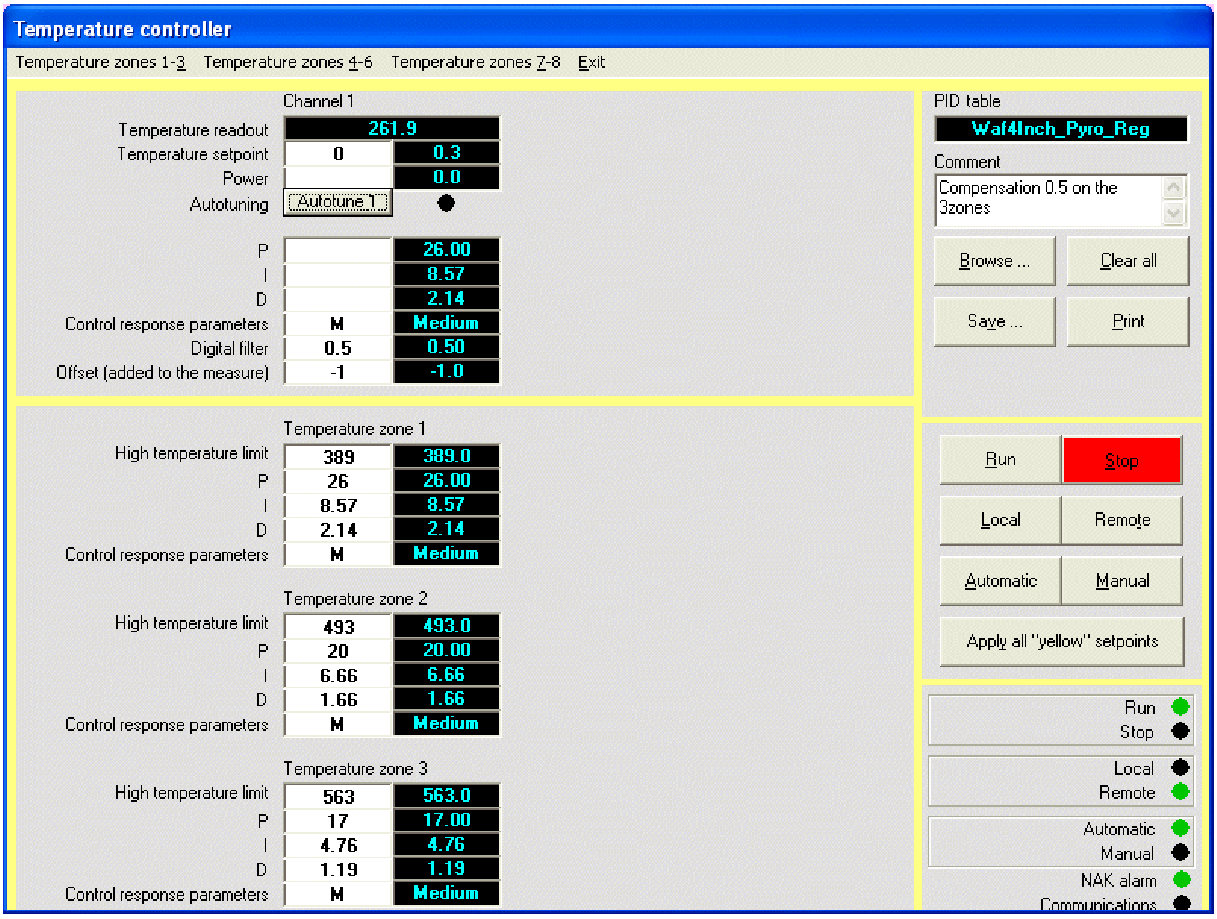
- Download an existing PID table (see **section 8.8.4**) or enter new set of PID parameters in the temperature controller interface.
  The system is provided with default PID tables for thermocouple and pyrometer regulation according to the substrate (Si, SiC with susceptor, SiC box) and to your applications. Those tables are given for process at atmospheric pressure, without any gas circulation in the chamber. They are to be adjusted according to real processing conditions, especially under vacuum.



NOTICE

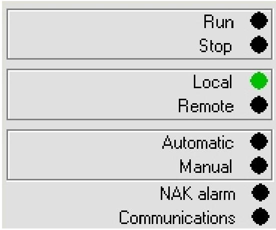
PID tables are specific to the temperature regulation mode used: thermocouple or pyrometer regulation. Do not use a PID table dedicated to thermocouple regulation if you are running under pyrometer regulation, and vice versa.

- Click on "**Apply all yellow setpoints**". This command sends all parameters to the temperature regulator. Check if parameters are well applied to the regulator, comparing the left and right columns of *Channel 1*. Check that values of black and white columns are the same. If not, re-enter the high temperature limit for each temperature zone (1 to 8) and press "Apply all yellow setpoints" command button again.



- Enter 0 as setpoint in the "Temperature setpoint" field and press ENTER;
- Switch to **Local mode** in the temperature controller interface in order to run the **Autotuning** on the regulator;

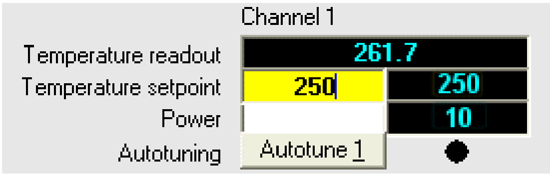
- When you select **Local**, the respective communication signal switches to green;



- In pyrometer regulation, remember that temperature readout, temperature setpoint and high temperature limit values are expressed in mVolt with a factor of 0.13. This value depends on the pyrometer calibration table used with your recipe.

$$PyroValue = Voltage \times 0.13$$

- As the furnace is "cold", ones needs to heat the furnace step by step. Enter steps of 50 unit of "PyroValue" and press ENTER. Increase temperature setpoint until value is at 10 unit of "PyroValue" below the pyrometer temperature readout;



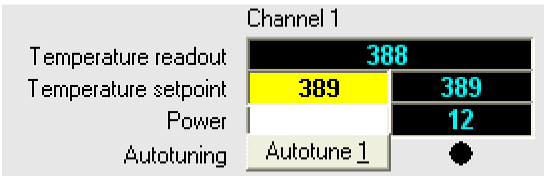
- Then enter a temperature setpoint just above this temperature readout (between 10 and 20 units of "PyroValue") and press ENTER. Wait a few seconds;

- Enter temperature setpoint with "half "step to increase temperature of the furnace until ones get close to the temperature readout value of the pyrometer shown on screen;

$$Halfstep = \frac{(PyroValue_{n+1} - PyroValue_n)}{2} \times 0.13$$

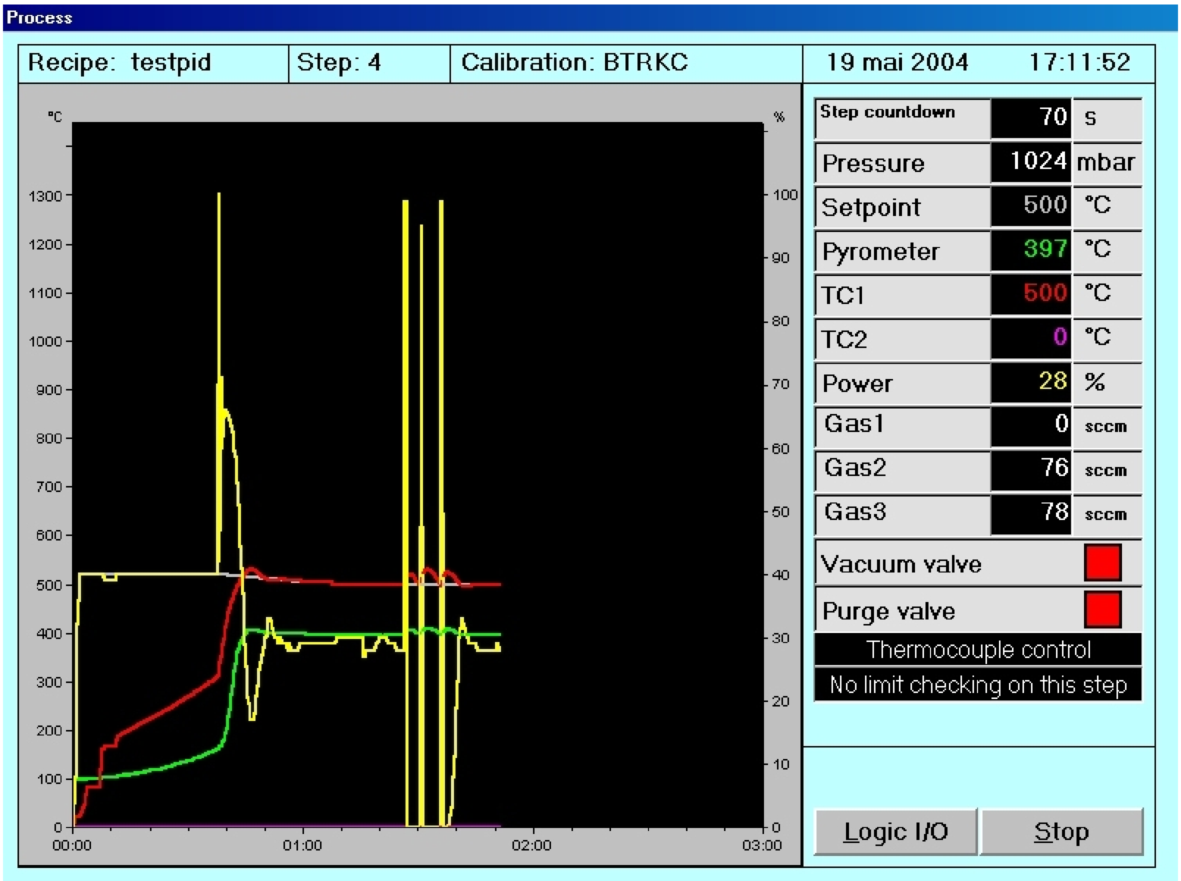
For PyroValue $_n$ use high temperature limit value of temperature zone n
For PyroValue $_{n+1}$ use high temperature limit value of temperature zone n+1

- **Enter** the first temperature setpoint for **autotuning.** Temperature setpoint has to be equal to the high temperature limit of temperature zone 1. Press ENTER and wait for temperature stabilization;

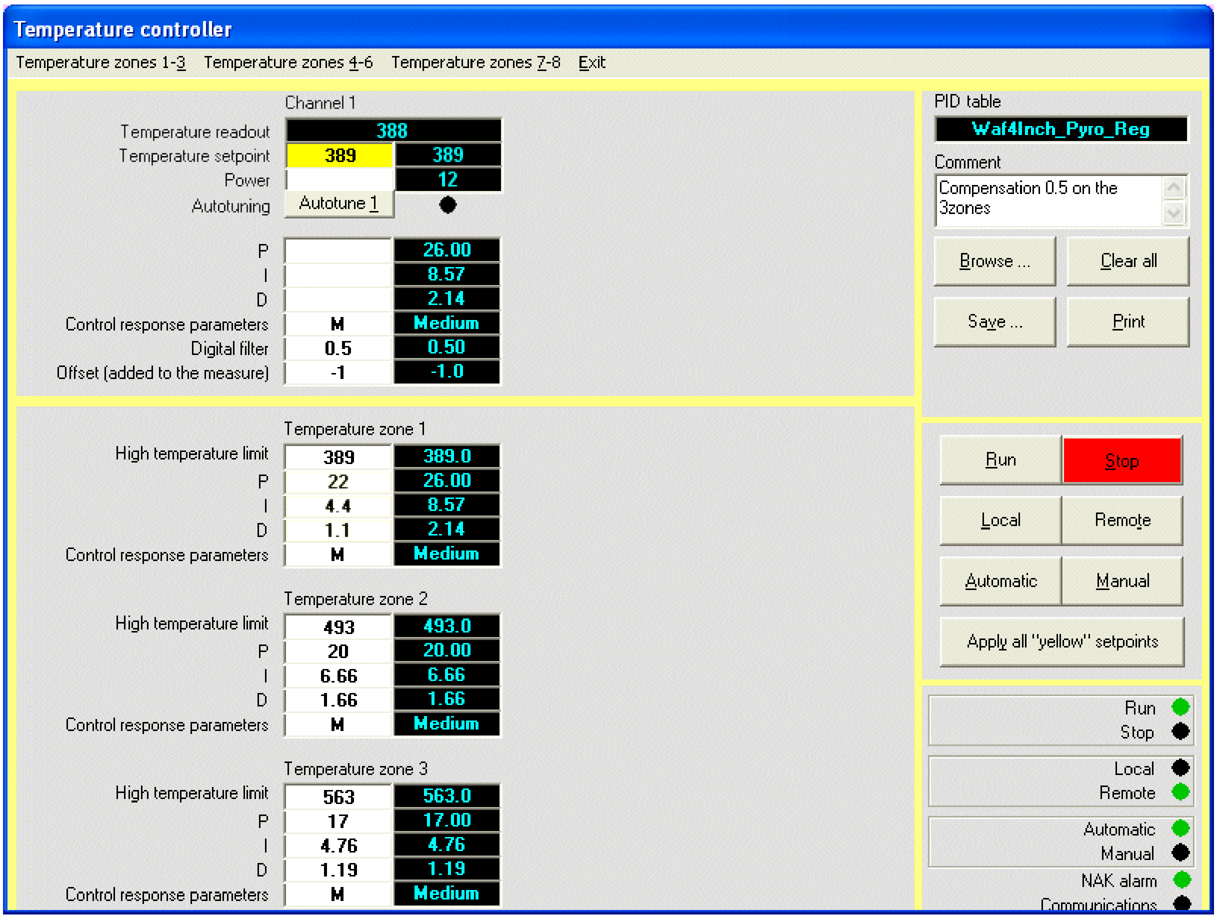


- Press **AUTOTUNE 1**. During autotuning, the communication signal switches to **green** till the end of the autotuning sequence.

NOTICE **This sequence sets the power setpoint from 0% to 100% three times. After the first pick, the system waits that the readout gets back to the setpoint value to perform the second pick of power. Same behavior is repeated three times. This recovering time depends on setpoint value, process conditions and substrate material.** **DO NOT ACT ON THE SYSTEM DURING AUTOTUNING SEQUENCE.**



- Once autotuning is done, PID parameters are automatically stored in the black cells in the corresponding *Temperature zone* part of the temperature controller interface. For example, the temperature setpoint 389, as shown below, appears on zone 1;

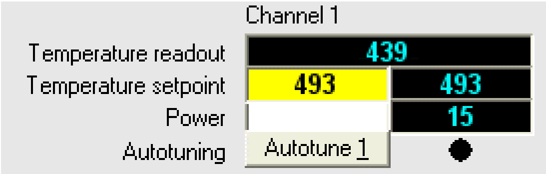


- Write down on a sheet of paper the PID parameters of the autotuned temperature zone 'x' (with x = 1 to 8);
- To ease the calculation and stabilization of next temperature setpoint autotuning, enter in temperature zone 'x+1' the PID parameters of temperature zone 'x'. Click on "**Apply all yellow setpoints**" to send the PID parameters to the temperature controller
- Enter temperature setpoint with "half "step to increase temperature of the furnace until ones get close to the temperature readout value of the pyrometer shown on screen;

$$Halfstep = \frac{(PyroValue_{n+1} - PyroValue_n)}{2} \times 0.13$$

For Setpoint $_n$ use high temperature limit value of temperature zone n
For Setpoint $_{n+1}$ use high temperature limit value of temperature zone n+1

- Enter the next temperature setpoint



- **Repeat** the autotuning sequence for **each temperature zone (1 to 6)**. Repeat sequence for temperature setpoints up to 900°C;
- Before the last two autotuning steps (temperature zone 7 and 8), let the furnace cool down few minutes;
- Heat up again the furnace step by step. Enter steps of 50 unit of "PyroValue" and press ENTER. Increase temperature setpoint until value is at 10 unit of "PyroValue" under the high temperature limit for zone 7. Wait for temperature stabilization;
- Enter temperature setpoint with "half "step to increase temperature of the furnace until ones get close to the temperature readout value of the pyrometer shown on screen;
- Perform the last two autotuning steps till 1100°C;
- Switch to **Remote mode** to quit the autotuning mode;

- Once all sets of PID parameters are defined, open a **PID table** and **save it as** a new name, using an explicit filename (substrate, temperature regulation).

- Then **retype each PID parameters** (the ones written on the sheet of paper) for each temperature zone, respecting the increasing temperature limit rate.
- Finally save the PID table.

IMPORTANT NOTICE

Do not forget to save the PID table once the autotuning has ended and check that you are in REMOTE mode before closing the temperature controller interface window.

CHAPTER 9. TROUBLESHOOTING

9.1. ALARM BEHAVIORS

The computer communicates with the SAIA PCD automaton via an RS232 link. A number of messages are displayed if an error occurs.

If any utilization condition is not fulfilled, the system is protected by alarms and safeties. When an alarm is declared by the PIMS, a message appears on screen, so the user is informed immediately. The alarm relay is activated.

Here is a full list of the error messages displayed through the PIMS dialog boxes:

Alarm#	Description
1	AIR FAILURE
2	WATER FAILURE
3	LAMP FAILURE
4	OVERHEATING
5	THERMOCOUPLE FAILURE
6	PYROMETER FAILURE
7	TEMPERATURE CONTROL FAILURE
8	PUMP FAILURE
9	PRESSURE ALARM
10	CHAMBER OPEN
11	VACUUM VALVE DID NOT OPEN
12	FORE PUMP VALVE DID NOT OPEN
13	FORE PUMP VALVE DID NOT CLOSE
14	TURBO GATE VALVE DID NOT OPEN
15	TURBO GATE VALVE DID NOT CLOSE
16	PROCESS TERMINATED BY OPERATOR
17	ALARM GAS 1
18	ALARM GAS 2
19	ALARM GAS 3
20	ALARM GAS 4
21	ALARM TEMPERATURE BAND LIMIT
22	MANUAL HEATING WATER FAILURE
23	MAINS FAILURE
24	H2 SAFETY INTERLOCK
25	PRESSURE SENSOR FAILURE
26	TURBO PUMP FAILURE
27	TURBO PUMP SPEED
28	LAMP BREAKER ALARM ZONE 1
29	LAMP BREAKER ALARM ZONE 2
30	LAMP BREAKER ALARM ZONE 3
31	FAN BREAKER ALARM
32	ACTIVE GAS INTERLOCK

Depending on the importance of the failure, the error is not managed in the same way: There are two levels of alarm depending on the risk.

The PIMS controls how there are displayed:

- **Alarms set in the "*Configuration window*"**: You can choose the action executed when the alarm is ON. The error is displayed in the process window or the process is stopped. It is not saved and neither displayed in the alarm historical. Thresholds can be set for temperature setpoint, pressure and gas flow. See **section 8.6.2** for details.
- **Alarm dialog box**: A dialog (as shown below) is displayed and the process is automatically stopped. The alarm is saved in the historical window.

- In this case, press "**OK**" to stop the alarm, the safety cycle starts. Prior to any new process, please solve the problem.

9.2. TROUBLESHOOTING

9.2.1. Water failure

The water flow sensor detects a low flow. The system stops.

Possible causes:

- The water supply tap is off;
- The water pressure is not sufficient;
- The water flow sensor is not well adjusted;
- A water leak in the circuit.

9.2.2. Air failure

The air pressure switch detects an air failure and stops the system.

Possible causes:

- No compressed air supply;
- Compressed air pressure is below 6 bars;
- The pressure switch is not well adjusted.

9.2.3. Fan failure

The fan circuit breaker has been cut off. The "**Initialization**" process must be launched.

Possible causes:

- Motor is overloaded;
- Circuit breaker has been cut off.

9.2.4. Furnace overheating

Temperature switch on furnace has detected an overheating.

Possible causes:

- Water flow is not sufficient;
- Too long processes.

9.2.5. Lamp failure

The controller detects a bad balance on a single heating zone. Same detection is performed on each zone. The system stops.

Possible causes:

- One lamp filament is broken;

9.2.6. Lamp breaker zone failure

A thyristor block on zone 1, 2 or 3 does not work. The system stops.

Possible causes:

- Circuit breaker on one zone has been cut off.

9.2.7. TC failure

Thermocouple failure. The system stops.

Using thermocouple temperature control, the thermocouple is broken. Change either the thermocouple or the temperature control mode.

9.2.8. Pyrometer failure

The system receives no signal from the pyrometer.

Possible causes:

- Pyrometer disconnected;
- Pyrometer failure;
- Readout converter failure.

9.2.9. Temperature control failure

Temperature control failure. The system stops.

Difference between the temperature readout and the setpoint.

Possible causes:

- No wafer in the chamber;
- Pyrometer failure;
- Lamps supply failure.

9.2.10. Vacuum valves failure

The alarm is raised if the actual state of a vacuum valve does not match the one expected by the PIMS. The turbo gate valve TGV and the forepump valve FPV are closed whenever the chamber pressure is over 50 mbar.

Failure suitable for:

- Turbo gate valve;
- Forepump valve.

9.2.11. Primary pump failure (optional)

The primary pump is powered off. Its circuit breaker is open. The system must be reset.

Possible causes:

- Pump motor is overloaded;
- Circuit breaker is open.

9.2.12. Turbo pump malfunction failure (optional)

If the turbo pump returns a malfunction error, pump is stopped. Process is stopped and cooling sequence starts. To reset the malfunction alarm, you need to act on the turbo pump circuit breaker (Q08) located in the electrical cabinet and to re-arm it.

Possible causes:

- Motor is overloaded;
- Circuit breaker is open;
- Over pressure inside the pump;
- Overtemperature.

9.2.13. Turbo pump rotation speed failure (optional)

If the turbo pump returns a RSA error, pump is stopped. Process is stopped and cooling sequence starts.

This alarm occurs when the rotation speed is under the internal speed threshold of the turbo pump.

Possible causes:

- Motor is overloaded;
- Overpressure.

CHAPTER 10. TEMPERATURE SENSORS AND CONTROLLERS

10.1. TEMPERATURE CONTROL

Jipelec systems are provided with closed loop temperature control with thermocouple or optical pyrometer. The system can also be used in power mode (open loop).

Temperature control devices:

- One optical pyrometer for process temperature measurement;
- Two K-type thermocouples for pyrometer calibration and low temperature measurement;
- RKC regulator for temperature control.

10.2. CONDITIONS OF USE

Thermocouples:

Lead free thermocouples can be used from ambient temperature up to 1000°C and only with non-active gases. When they are used under other conditions, their lifetime is much shorter and in some cases, it is impossible to use them (reducing atmosphere for example). Sheathed thermocouples can be supplied for special applications. The sheathed thermocouples are strongly recommended for temperature control of susceptors.

The lifetime of the thermocouple is really reduced in reducing atmosphere if you use a lead free thermocouple as the welding has some oxide that protects it and that will be removed in reducing atmosphere. The lifetime can be as short as few process cycles. If you use a sheathed thermocouple it has an Inconel sheath with good resistance to different type of gas atmospheres.

Susceptor:

For the **susceptor temperature control**, use a **sheathed thermocouple** installed in the small hole of the thermocouple on the **edge of the susceptor** (and even more if you have a reducing atmosphere). We have performed some pyrometer control in some cases. First case is control of a sample on a susceptor but without cover and if the ramp rate is not too high. This system, with a pyrometer on the edge, allows pyrometer temperature control with the susceptor. Anyway for most of the applications with susceptors use the sheathed type thermocouples. The central TC (on backside) will limit the temperature control capabilities because of the thermal inertia of the system and the response time.

The temperature uniformity is another issue and cannot be measured by thermocouples installed outside the susceptor. The **susceptor with a large edge** allows reducing the edge effect on the sample and getting a **good uniformity** on the sample to be processed inside the box.

Pyrometer:

The system is usually provided with one optical pyrometer for high or low temperature control range depending on the application. The pyrometer looks at the rear side of the substrate and only receives signal from the substrate and not from the lamps.

10.3. TEMPERATURE CONTROL OF SUSCEPTORS

The temperature control of susceptor is more complicated than with a single wafer because the thermal system (susceptor, sample and cover) is much more complicated and has a much bigger thermal inertia. This leads to lower ramp rates for both heating and cooling and to some big overshoot when using fast heating rates. Hereafter are some recommendations to improve the temperature control with a susceptor.

10.3.1. How to improve temperature control?

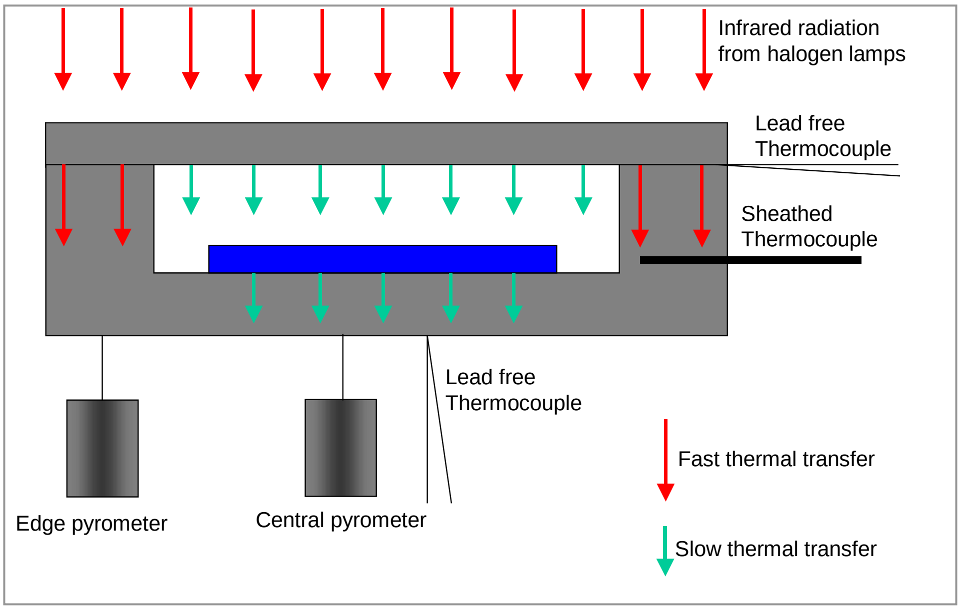
The drawing hereunder describes the heating exchanges between the lamps, cover, sample and susceptor:

- On the edge, the lamps heat the cover from the upper side. The heat is directly transferred from the cover to the susceptor;
- In the middle the lamps heat the cover and then the cover heats the sample by radiation (with much less power than the lamps); then the sample heats the susceptor.

The thermal exchanges are much faster on the edge than in the center and for this reason it will be much easier to control the temperature measuring the temperature on the edge because the response time is much faster. This is especially interesting when high heating rates are required.

The edge temperature measurement methods are:

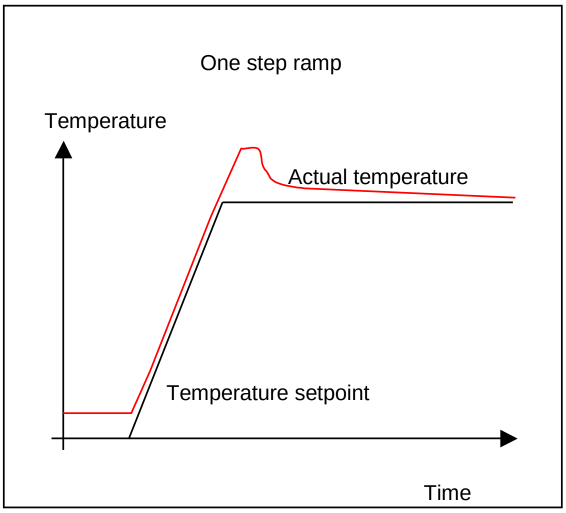
- Edge pyrometer from the backside (On some RTP systems only);
- Sheathed thermocouple in the special hole on the edge of the susceptor. This allows measuring the temperature very close to the sample. This method is recommended as the temperature is close to the sample temperature and the response time is short;
- Lead free thermocouple installed between the susceptor and the cover).

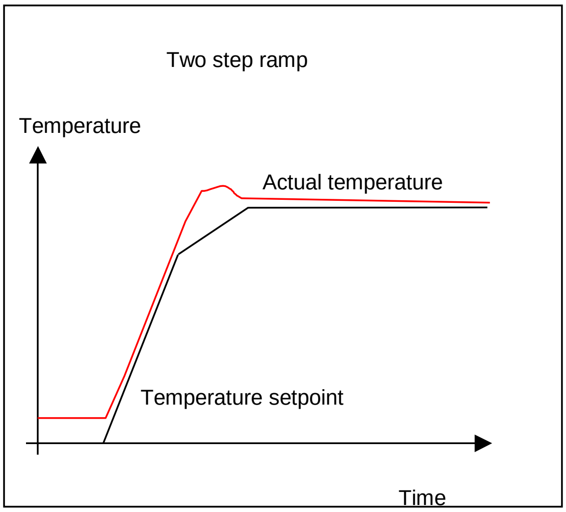


10.3.2. How to reduce the overshoot?

A better temperature control method as described above can reduce the overshoot as the control system may have a better response time. For example a sheathed thermocouple installed in the hole on the edge of the susceptor will have a much shorter response time than a lead free thermocouple installed in the backside and center of the susceptor because here the thermal exchanges are much faster.

If there is still high overshoot for the heating ramp there is another way to overcome this problem or at least to reduce the overshoot using a two step ramp. The method is described in the drawing hereafter. This requires some process engineering but as the reproducibility of the system is good the method can be of some interest for a better process control.





10.4. OPTICAL PYROMETER

System is provided with one optical pyrometer for low or high temperature control range. The pyrometer looks at the back side of the substrate (three positions are available, see figures in appendix) and only receives signal from the wafer (or susceptor) and not from the lamps.

For **accurate** and **repeatable** regulation, check the pyrometer calibration regularly. A six-month period appears to be the average reliability of the calibration. However, if the system is often used at high temperature (over 1000°C), it is recommended to calibrate the pyrometer more frequently.

Low temperature (LT) pyrometer specifications:

- Wavelength range: 8 to 14 µm;
- Type: LT (low temperature);
- Temperature range: 0°C to 900°C;

High temperature (HT) pyrometer specifications:

- Wavelength: 5.14 µm;
- Type: HT (high temperature);
- Temperature range: 100°C to 1300°C.

Note: Above temperature range values are given for silicon wafer or SiC coated susceptor only. Pyrometer regulation is performed by the RKC regulator. The calibration tables are saved on the computer hard disk as well as the set of PID parameters from the RKC module. It is possible to save different tables for different substrate materials and to associate them to process recipes. The set of PID parameters have to be selected from the **Temperature controller interface** (see **section 8.8** for full details on the temperature controller).

Pyrometer calibration

Pyrometer calibration is an essential operation. A good temperature measurement will result from the quality of calibration. The pyrometer measures a quantity of infrared radiation. The quantity of radiation depends on:

- Substrate nature (Silicon, GaAs, Graphite, etc.);
- Nature of layers on substrate surface;
- Temperature of substrate.

Some substrates, especially GaAs, may have their optical properties definitely changed if they reach some temperature levels. The calibration must be always performed with a substrate with the same "**thermal past**" than the substrates that have to be processed in the system.

Notice that Silicon and GaAs are transparent for infrared at low temperature. In the same way the pyrometer can see the lamps through the wafer at low temperature.

Usually the calibration does not change for the same type of substrate. If calibration changes check that the pyrometer window is clean, and that the pyrometer emissivity has not been changed.

The calibration has to be performed whenever the type of substrate or the process conditions are changed.

NOTICE

Like for the thermocouple, because of the temperature control system (proportional type), a difference appears between the setpoint and the actual measurement. A RKC regulator permits to compensate this difference for both thermocouple and pyrometer.

CHAPTER 11. MAINTENANCE

11.1. PERIODICITY OF MAINTENANCE OPERATION

Respect the periodicity of maintenance operations. The periodicity of operation is strongly linked with process applications and must be adapted to the application.

The metallic housing protects the operator form contacts with powered parts.

During maintenance or adjustments, the system must be **powered off**.

CAUTION
Some parts inside the system may remain powered-up. These operations must be carried out only by factory, trained technicians.

Feel free to contact Qualiflow Therm engineers for more details about servicing and maintenance operations.

11.1.1. Reactor

Operation	Periodicity	Comment
Cleaning the reactor windows	6 months	
Cleaning the processing chamber	When needed	Depends on process
Cleaning the pyrometer window	1 year	Depends on process
Calibrating the pyrometer	2 months	
Controlling the platen "O-ring	1 year	

11.1.2. Furnace

Operation	Periodicity	Comment
Replacing lamps	When 1 filament is blowing or broken	Recommended to change all the lamps of the zone
Cleaning the reflector	When changing lamps	
Control of the electrical connections	1 year	

11.1.3. Electricity

Operation	Periodicity	Comment
Replace the SAIA controller battery	1 year	Chapter 11.9
Control of the electrical connections	1 year	

11.1.4. Gas and vacuum

Operation	Periodicity	Comment
Check gas panel and gas line tightness	1 year	
Change gas filters	1 year	
Perform a leak test of the process chamber	1 year	
Mass flow controllers calibration	1 year	

11.1.5. Water and compressed air

Operation	Periodicity	Comment
Check water circuit tightness	1 year	

11.1.6. Safety

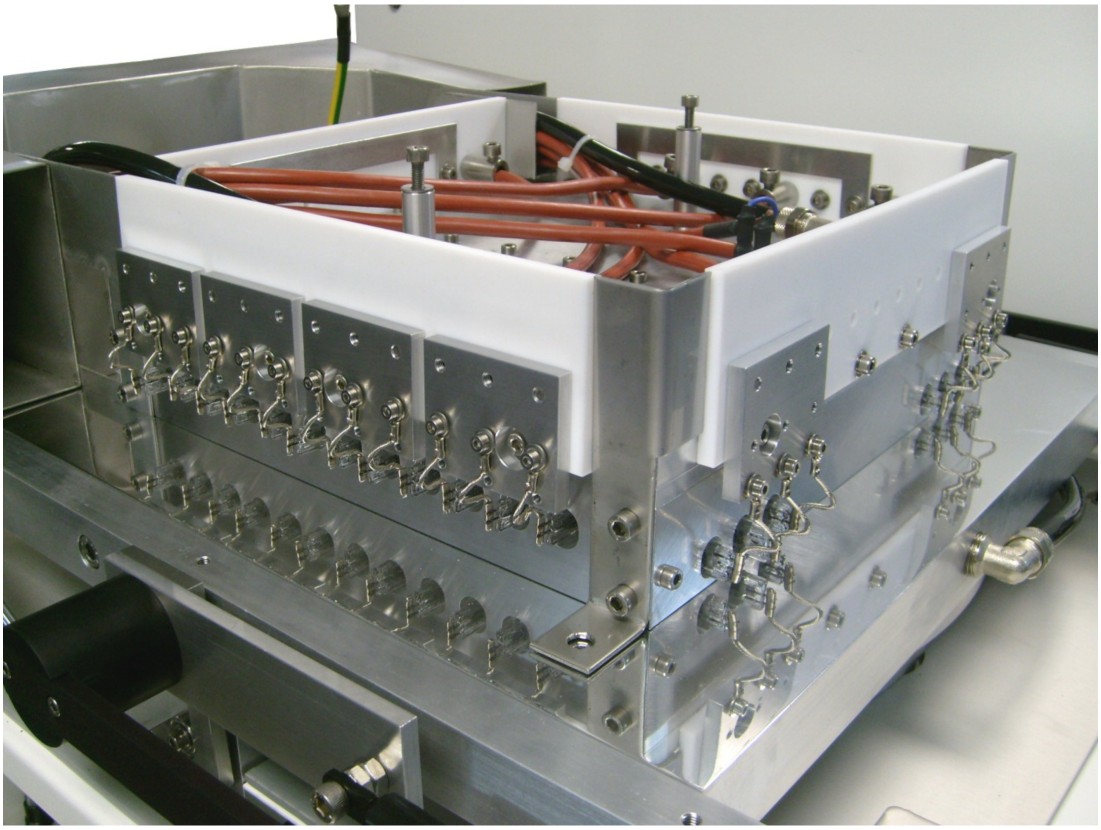
Operation	Periodicity	Comment
Check safety interlocks and sensors adjustments	1 year	

11.2. CHANGING LAMPS

See **fig. 1** in appendix.

Procedure to change a broken lamp:

- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- Remove the metallic reactor box (white cover);
- Remove the stainless steel furnace protection;



- Remove electrical connections of lamps and gently remove lamps (**using gloves**);
- Never touch the lamps with bare fingers, otherwise clean them with alcohol;
- Before dismantling a lamp, take care to straighten the electrical wires of the lamp to ease its way out of the furnace chassis;
- Re-install lamps using the same procedure in reverse order;
- Turn on the main circuit breaker and start the system.

11.3. CHANGING THE QUARTZ WINDOW

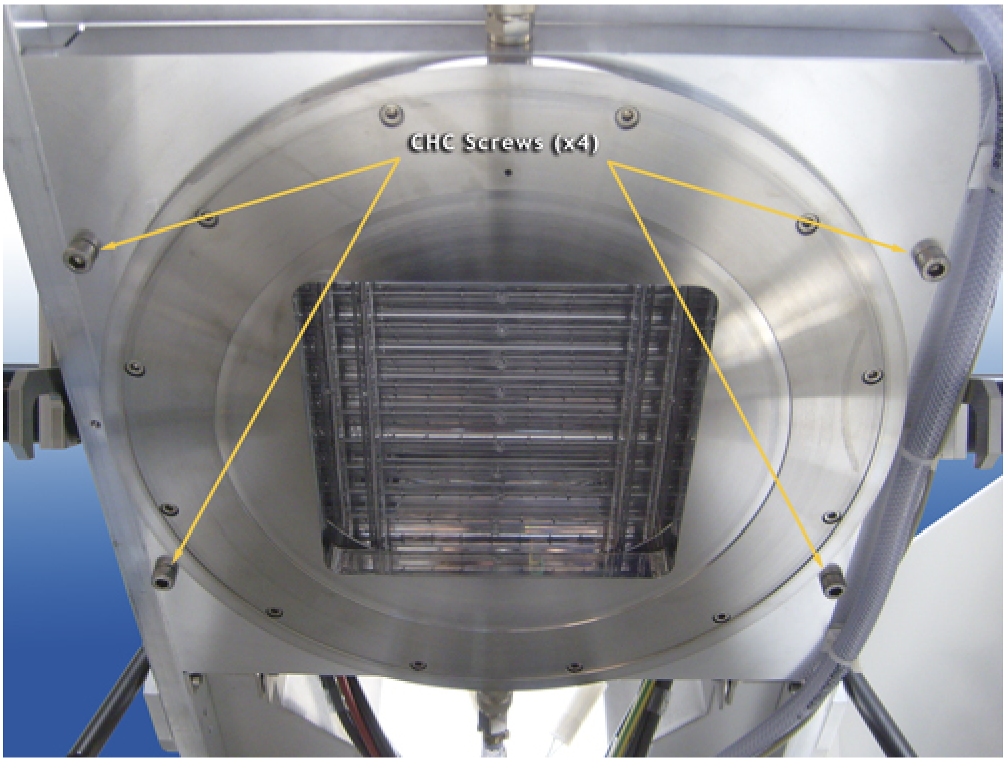
The procedure is the same for square or round chamber. Only the chamber flange shape at the center is different, round or square.

IMPORTANT NOTICE

Two or three technicians are necessary to hold the upper platen and remove all CHC screws. This operation must be carried out only by trained and qualified technicians. Work with gloves.

Dismantling the window:

- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- Remove the left side panel;
- Purge the water circuit;
- Close the purge gas valve (line 1);
- Lift-up the reactor and remove sample and quartz pins;
- Disconnect the water pipes, equipped with quick fittings;
- Unscrew the 4 CHC screws. **Take care as assembly is heavy**, do not operate alone;



- Work on a flat and soft surface.
- Unscrew the 12 CHC screws to remove the chamber flange from the assembly;
- Remove the window and the O-rings.

Installing the new quartz window and the chamber flange:

- Check the cleaning of all pieces, otherwise clean them with alcohol;
- Place the quartz window onto the chamber flange (check there is the Viton O-rings);
- Place the 12 CHC screws back and tighten carefully in cross the screws of the chamber flange;
- Put the assembly on the equipment and screw the four CHCs back;
- Connect the water pipes, equipped with quick fittings;
- Open the purge gas valve (line 1);
- Turn on the main circuit breaker and start the system;
- Open the water circuit and test tightness (enter the "Manual mode" in the PIMS software);
- If necessary, re-tighten the 12 screws of the chamber flange;
- Put back the left side panel;
- System is ready.

11.4. CHANGING THE TOP CHAMBER FLANGE

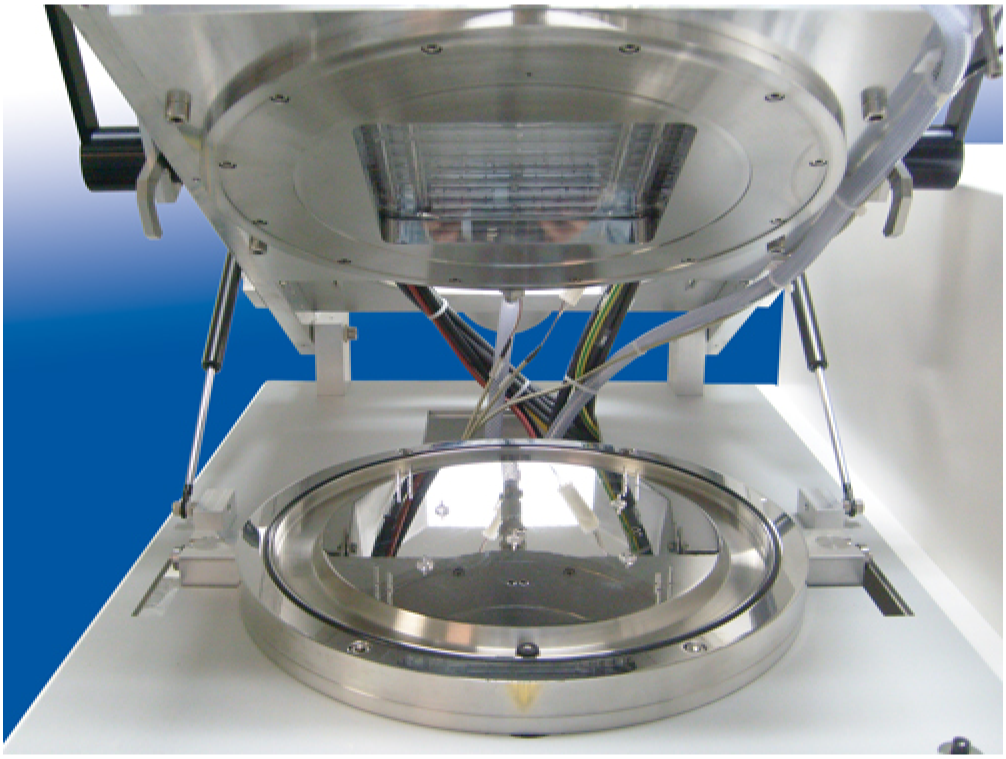
If you want to change the top chamber flange from round to square chamber and vice versa, use the following procedure. This is the same as previous chapter but the dismantling of the quartz window. Only the chamber flange shape is different, round or square.

> **IMPORTANT NOTICE**
> **Two or three technicians are necessary to hold the upper platen and remove all CHC screws.**
> **This operation must be carried out only by trained and qualified technicians.**

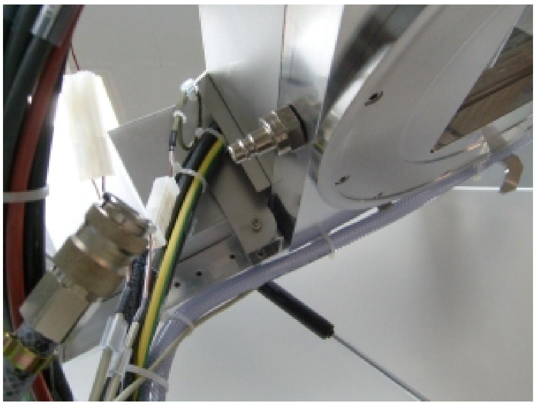
See **fig. 1** in appendix.

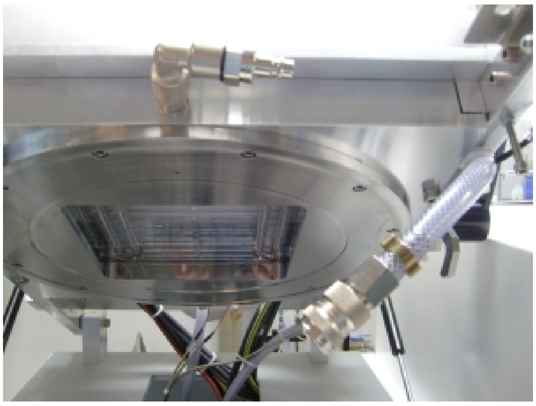
Dismantling the top chamber:

- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- Remove the left side panel;
- Purge the water circuit;
- Close the purge gas valve (line 1);
- Lift-up the reactor and remove sample and quartz pins;

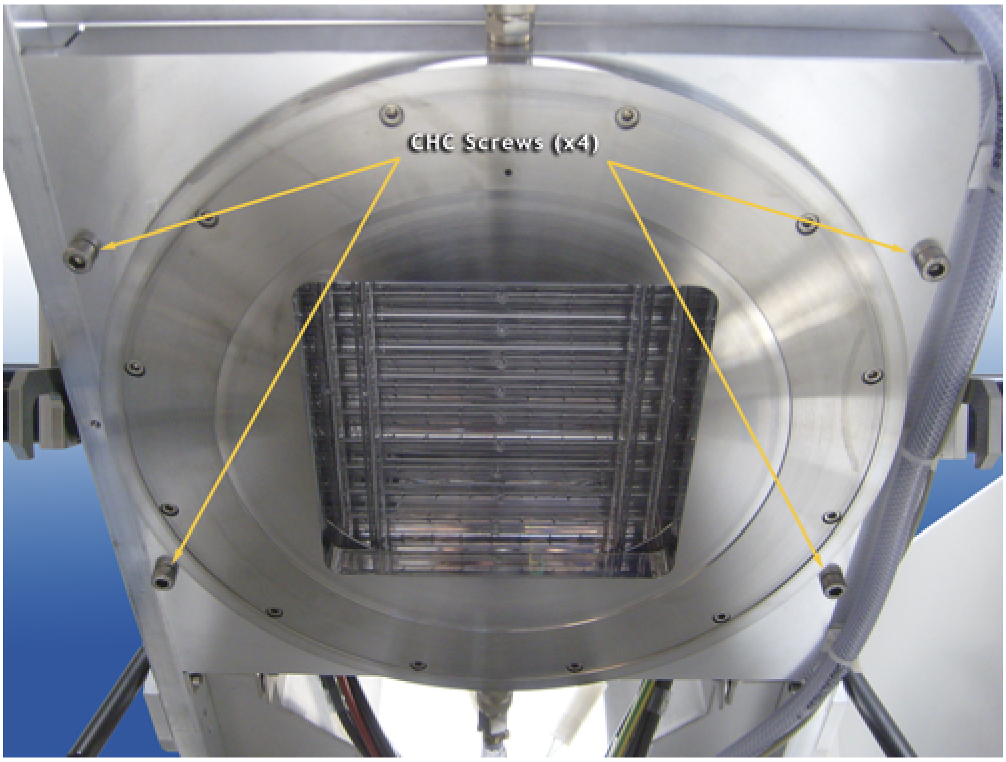


- Disconnect the water pipes, equipped with quick fittings;





- Unscrew the 4 CHC screws. **Take care as assembly is heavy**, do not operate alone;



- Work on a flat and soft surface.

Installing the spare top chamber:

- Check the cleaning of all pieces, otherwise clean them with alcohol;
- Put the assembly on the equipment and screw the four CHCs back;
- Connect the water pipes, equipped with quick fittings;
- Open the purge gas valve (line 1);
- Turn on the main circuit breaker and start the system.
- Open the water circuit and test tightness (enter the "Manual mode" in the PIMS software);
- If necessary, re-tighten the 12 screws of the chamber flange;
- Put back the left side panel;
- System is ready.

11.5. CHANGING THE REACTOR

The reaction chamber of the system can be changed quickly to process different type of sample, from wafer to square cells and vice versa.

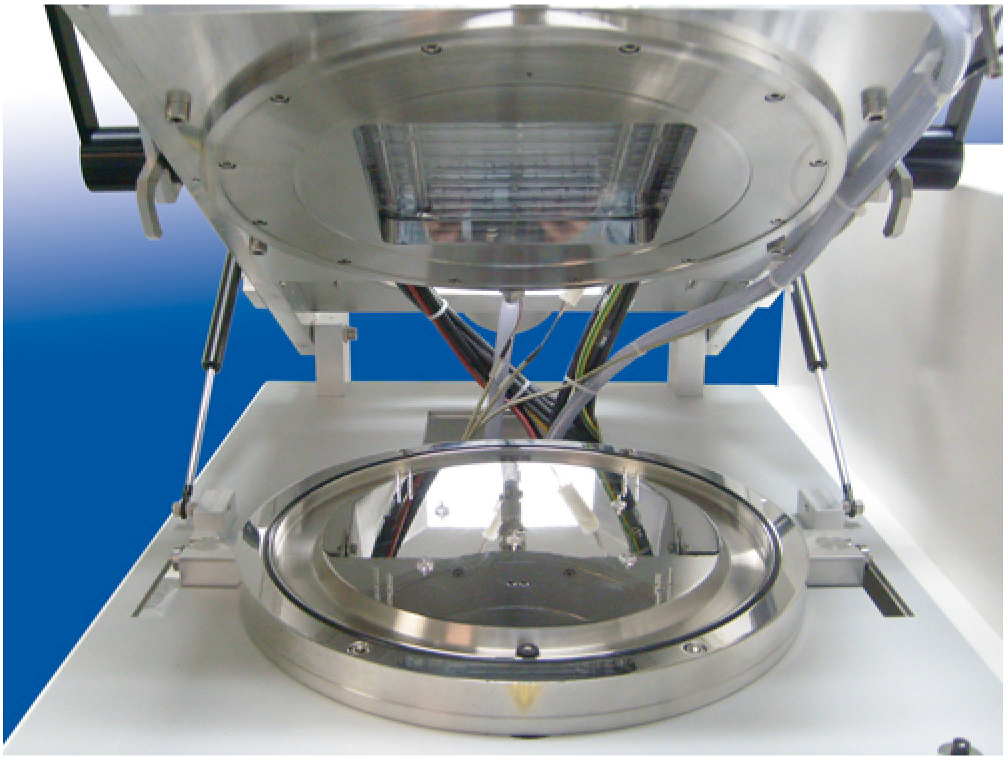
IMPORTANT NOTICE

Two technicians may be necessary to hold the reactor platen. This operation must be carried out only by trained and qualified technicians.

See **fig. 1** in appendix.

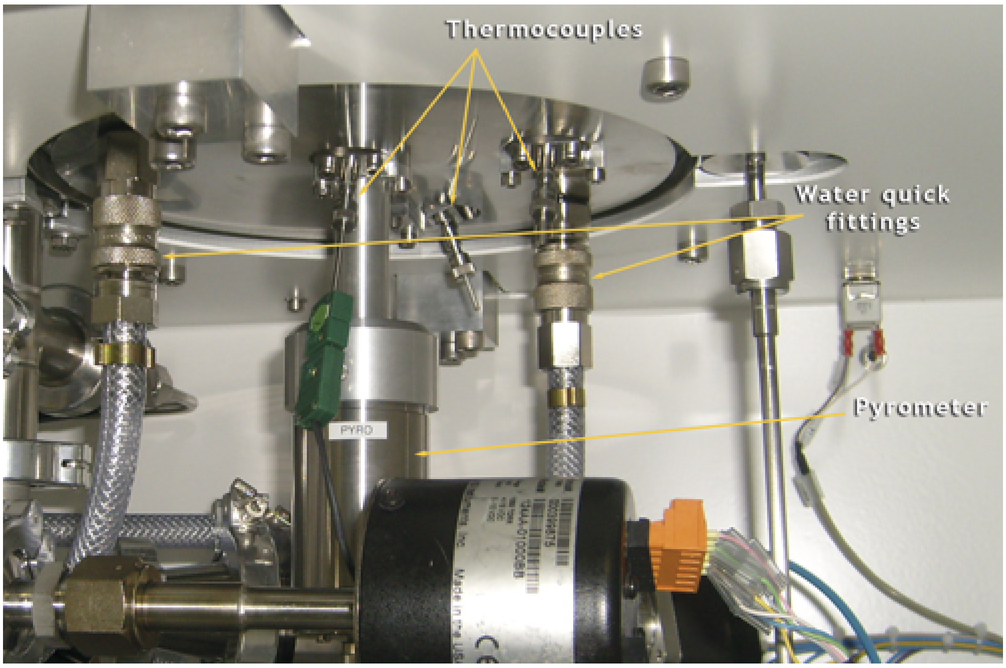
Dismantling the reactor platen:

- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- Remove the left side panel;
- Lift-up the reactor and remove sample and quartz pins;

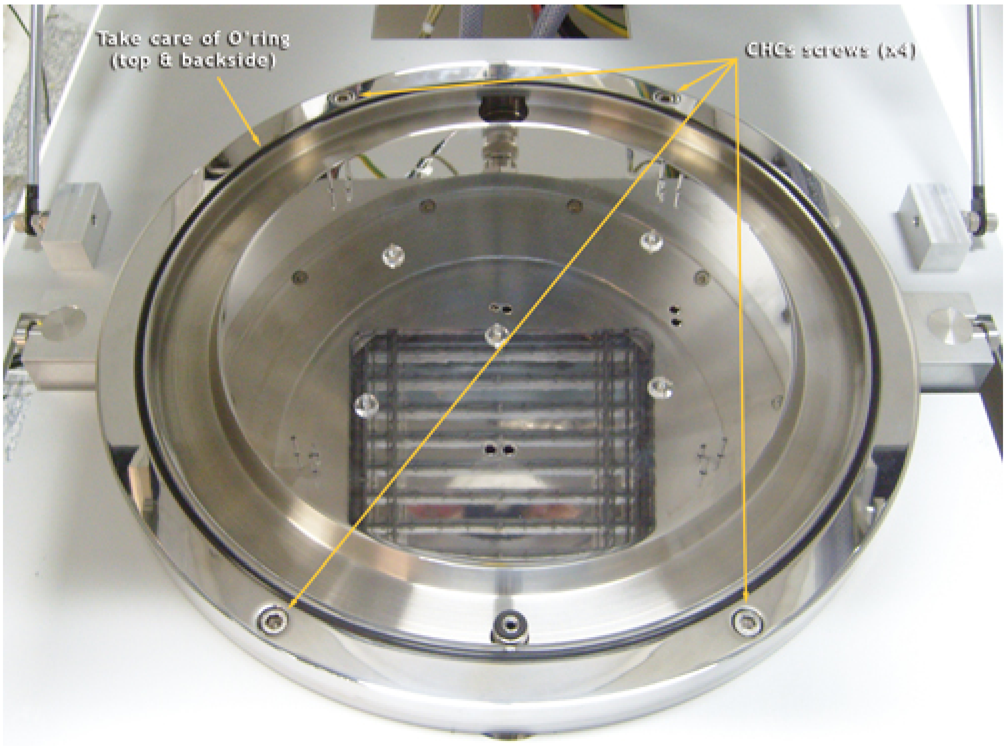


- Purge the water circuit;
- Close the purge gas valve (line 1);
- Under the platen, remove thermocouples;
- Remove the pyrometer (do not remove the sight tube);

- Disconnect the water pipes, equipped with quick fittings;

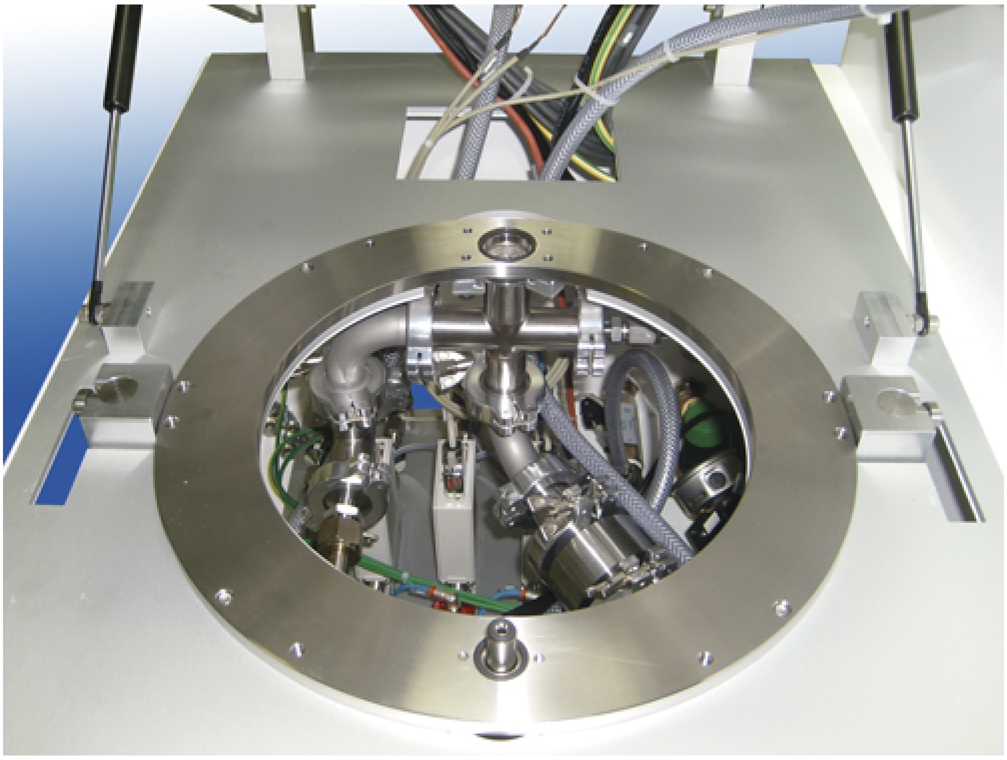


- On the platen, unscrew the 4 CHC screws;



- Take care of O'rings and gently remove the reactor from the equipment and work on a flat and soft surface.

Installing a spare reactor:



- Take the spare reactor and place it on the system taking care of O'rings;
- On the platen, screw the 4 CHC screws, tight in cross;
- Connect the water pipes, equipped with quick fittings;
- Open the purge gas valve (line 1);
- Install the pyrometer and thermocouples;
- Turn on the main circuit breaker and start the equipment. Open the water circuit and test tightness (use "Manual mode" in the PIMS software);
- If necessary, re-tighten the screws.
- Put the left side panel;
- Reactor is ready to process new sample.

11.6. CHANGING THE THERMOCOUPLES

Up to three thermocouples can be installed under the wafer through O-ring connectors, located under the reactor platen.

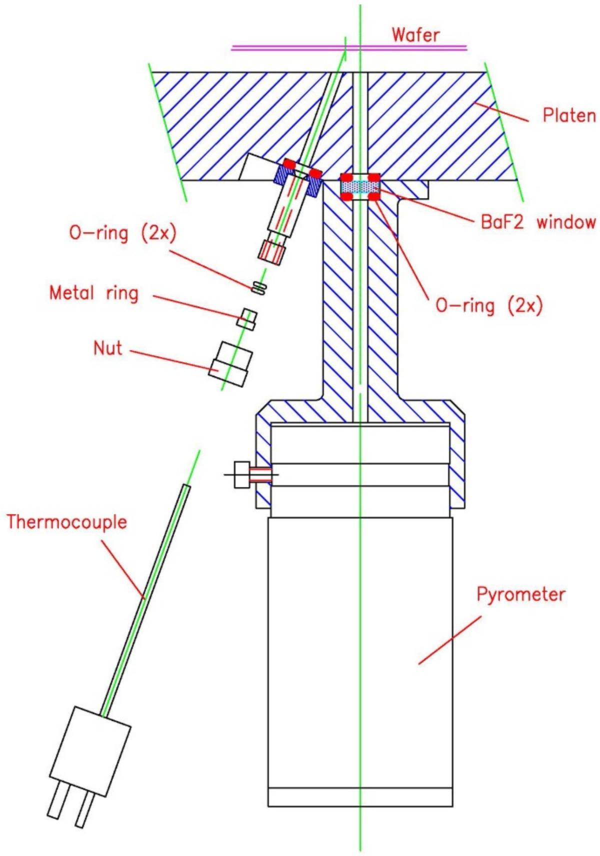
Threads are mounted in a stainless steel sheath and connected to a compensated plug. Tightness is obtained by an epoxy paste.

CAUTION

Thermocouple 1 (TC1) needs to be connected at any time. Only position of thermocouple 1 (TC1) has to be adjusted depending on process temperature. Move it down (but do not disconnect it) for process under pyrometer control at high temperature (>1000°C).

See **fig. 10** in appendix.

- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- Remove the left **metallic panel**;
- Under the platen you can see stainless steel **feed through** with Viton O-ring;



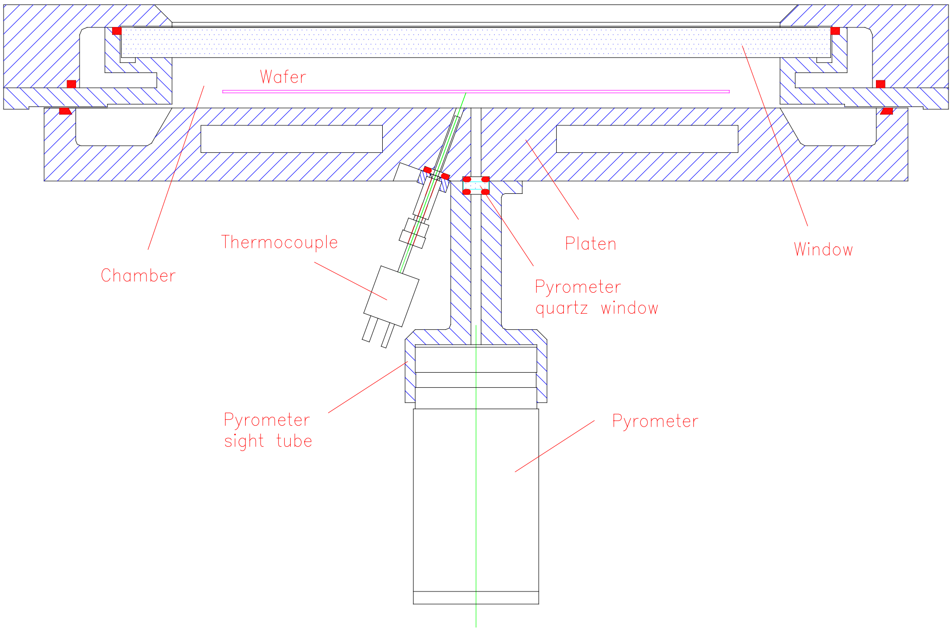
- Remove the **nut**, the small metallic **ring** and the two **O-ring**;
- Take the thermocouple place primary the nut, then, the ring and finally the two O-ring;
- Place this assembly inside the feed through very **carefully**;
- Push this till the welding threads **touch the wafer** installed on the quartz pins;
- **Screw the nut** to have the tightness.
- It is possible to readjust the thermocouple position to have a good contact with the wafer.
- Follow the same procedure in reverse order to remove the thermocouples.

11.7. DISMANTLING PYROMETER

For maintenance or positioning purpose, you may have to remove the pyrometer and / or the sight tube. For example if you want to change the pyrometer position, you will have to move the tube of sight of the pyrometer as well. If you want to clean the pyrometer quartz window, you have to dismantle the sight tube. Here is a short procedure to do so.

To change the pyrometer model, from a low temperature to high temperature model, you don't have to change the sight tube, but the pyrometer calibration has to be performed.

See **figures** in appendix and below for pyrometer location:



Procedure:

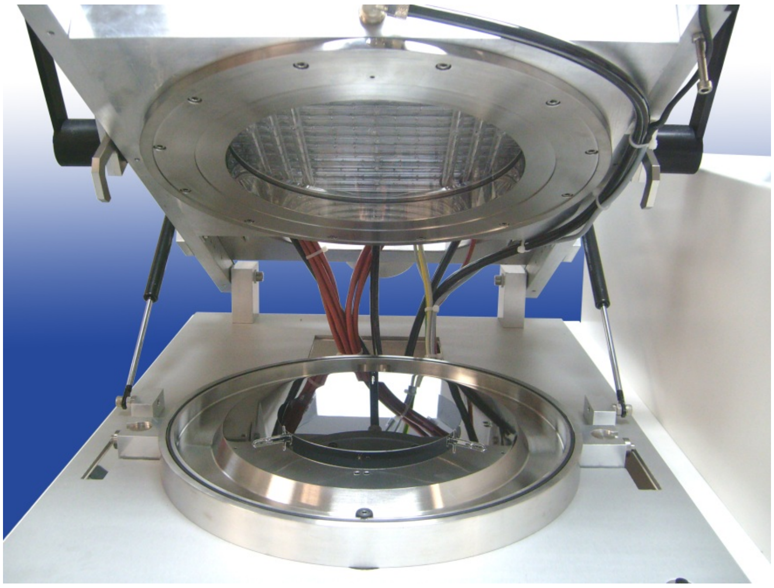
- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- Remove the left metallic panel;
- Disconnect its power supply cable;
- Unscrew the CHCs that supports the pyrometer;
- Unscrew the tube of sight (3 CHC screws) and take off the Viton O-rings and the pyrometer quartz window;
- Mount back the joints on the new tube, proper to the pyrometer used (HT or LT);
- Proceed in reverse order to mount the tube of sight and the pyrometer.

Once the pyrometer is changed, perform the pyrometer calibration. For further information, see **section 8.8.5.**

11.8. CLEANING THE REACTOR

Procedure

- **Press the "STOP" button and shut down** the main circuit breaker to power off the system;
- **Lift up** the chamber;



- Clean the chamber and the window with a lint free duster and alcohol or freon. Never use acetone because of the Viton O-ring;
- Pull the thermocouples and the quartz pins to clean the platen.

11.9. CHANGING CONTROLLER BATTERIES

The SAIA PCD3 controller uses Lithium battery to save user's recipe, and calibration tables in RAM.

Batteries can be replaced without risk of data loose until controller is supplied.

We recommend changing batteries every year.

Proceeding:

- Remove the right side metallic panel;
- Remove the blue SAIA controller cover located on the left of the electrical cabinet;
- Battery is mounted on the blue bar with led. Remove the old battery and installed the new one in the same direction;
- Reinstall controller cover and metallic panel.

11.10. CLEANING PROCESS FOR SILICON CARBIDE PRODUCTS (SOURCE POCO)

This section is part of POCOGRAPHITE Incorporation documentation and relates to the cleaning process of coated and uncoated SUPERSiC parts. Contact Qualiflow Therm engineers for further information.

DANGER

This procedure implies the use of toxic and corrosive chemicals. Authorized personnel must carry out cleaning operations with great care only.

QUALIFLOW THERM expressly disclaims responsibility for loss, damage or death caused by use of the chemicals listed below in the cleaning process other than in accordance with proper operating procedures. The user is considered to be aware of the effects of the gases and chemicals that he uses, as well as those of the decomposition products and gases generated by the processes in operation.

11.10.1. HF Cleaning Process

- Initial cleaning for all POCO Silicon Carbide parts;
- Re-cleaning of SUPERSiC coated parts;
- Re-cleaning of uncoated parts for low temperature oxidation*, low temperature diffusion, VD (poly, nitride and BPSG).

SiC articles may be cleaned using standard cleaning solutions, or by using a nitric-hydrofluoric acid solution as described below:

- Presoak the article in DI water for a minimum of 15 minutes. SiC coated product requires a minimum of 1 hour presoak;
- Immerse the article in the acid solution. Typical concentrations for hydrofluoric acid solutions range from 1:100 to 1:1 HF:H_2O. Concentrations for nitric/hydrofluoric solutions range up to 2:2:1 HF:HNO_3:H_2O. ** Immersion times typically range from 5 to 15 minutes; however, longer immersion times will not degrade the SUPERSiC material. Excessively long soaks are not recommended for coated parts;
- Rinse the article in a cascading de-ionized water system. Rinse time should be 30 minutes minimum typically at 6-8 gallons per minute. The article should be rinsed until original water resistivity is reached;
- Use the appropriate drying method for uncoated or coated parts.

Note: Do not leave SiC coated parts immersed in liquids for extended periods.

** The gate oxidation process should use SiC coated SUPERSiC parts. If you elect to use uncoated SUPERSiC parts, a typical passivation process of H_2O/HCl at 1200°C for 16+ hours should be performed on the uncoated SUPERSiC boats prior to use. Since this forms a Cl passivated SiO_2 layer on the SiC grain structure, further HF cleaning cycles should be eliminated or minimized to prevent long-term degradation of the SUPERSiC parts. If cleaning is required, we recommend the RCA Cleaning Process.*

***HF concentration 49%, HNO_3 concentration 70%.*

11.10.2. RCA Cleaning Process

Re-cleaning of uncoated parts for high temperature oxidation and high temperature diffusion**.**

Frequent HF-based cleaning will increase the oxygen reaction with the internal pore structure of the uncoated SUPERSiC.

If cleaning is required, we recommend the following procedure:

- 5:1:1 to 7:2:1 H_2O:H_2O_2:NH_4OH at 75°- 85° C for 5-15 minutes;
- 5:1:1 to 8:2:1 H_2O:H_2O_2:HCl at 75°-85° C for 5-15 minutes;
- DI H_2O cascade rinse described in the HF Cleaning Process;
- Use the appropriate drying method for uncoated or coated parts.

Note: Do not leave SiC coated parts immersed in liquids for extended periods.

11.10.3. Bake Methods

Fast Dry Method for Uncoated Parts:

- Bake the uncoated SUPERSiC parts in an oven to remove any residual moisture. Temperature should be 120° C to 150° C for a minimum of one hour using dry air or nitrogen;

Slow Dry Method for Coated Parts;

- SiC coated SUPERSiC parts require an extended drying process to remove residual moisture. Bake the coated SUPERSiC parts in an oven under dry air or nitrogen, following the three step time/temperature sequence below:
- 4 hours at 150° C;
- 30-60 minutes at 250°-300° C;
- 60-90 minutes at 400° C.

CHAPTER 12. PIMS SOFTWARE INSTALLATION

The minimum requested configuration is

- Pentium II PC or more 15” or more monitor;
- Windows 2000 or XP.

To install the software:

- Insert disk in the CD-Rom drive;
- Run using Windows "CD-Rom a:\setup".

Software information

PIMS control software is installed in “**C:\ProgramFiles\Jipelec**” directory by default.

Each recipe is saved as a single file with a “.rec” file extension under the “**Recipes**” directory.

Calibration and compensation tables are stored as separate files in the “**Tables**” directory.

Historical is stored in the directory "**Historical**".

It is recommended to make a back-up of those directories once a month.

CHAPTER 13. GRAPHITE PARTS – INFORMATION

Qualiflow Therm can provide graphite susceptors to work with. If you choose to purchase graphite susceptors, please read the following section. This presents the material features and how to work with graphite susceptors.

CAUTION

The SiC coated graphite susceptors and covers are sensitive to temperature gradients. These parts should not be used with temperature ramp rates over 50°C/s. The user must be aware that the gas injection (specially from reactor bottom side) can lead to high temperature gradient and breakage in susceptor and cover. Qualiflow Therm strongly recommends using small gas flow for processes with susceptor especially if temperature exceeds 600°C. Qualiflow Therm will not give any warrantee on the susceptor and covers. Contact Qualiflow Therm for further information.

13.1. INTRODUCTION

Qualiflow Therm provides SiC (silicon carbide) coated susceptors for heat treatment of small samples or compound semiconductors as well as for CVD processes.

SiC coated susceptors have a limited lifetime.

The most common phenomenon limiting the use of the susceptor is the occurrence of pinholes in the SiC coating. The susceptor cannot be used any more because of the contamination level or the formation of spots on the backside of the wafer. Recommendations are given to reduce pinhole formation.

The susceptors are also sensitive to temperature gradients.

13.2. THE SIC COATED SUSCEPTOR

Susceptors are made out of graphite because of:

- Good mechanical properties at high temperature;
- Good thermal conductivity for homogeneous temperature;
- Excellent resistance to thermal shock;
- Low thermal mass for fast heat-up rate;
- Low level of metallic impurities.

Graphite however is porous and releases graphite dust. In order to prevent this and to further increase purity, the susceptor is coated with a Silicon Carbide layer, by a CVD process. Proper selection of the graphite ensures a good adhesion of the coating and resistance to thermal shock.

13.3. THE SIC COATING

Silicon carbide is a hard and inert ceramic material. The chemical resistance of SiC is extremely good. The SiC is resistant to oxidation in air up to a temperature of 1800 C. During HCl etching, SiC is not thermodynamically stable. The kinetics however are such that even after thousands of etch cycles, no reduction of the SiC coating thickness can be measured. Conditions that enhance etching of the SiC coating are reduced pressure and the presence of metals.

13.4. PINHOLE FORMATION

In spite of the inertness of SiC, small and large holes can develop in the SiC coating. Pinholes have a size in the order of 0.1 mm.

The pinholes are often visible by a gray or yellow discoloration around a hardly visible hole. In virtually all cases, the presence of metals is responsible for the creation of the pinholes. As an example, the use of stainless steel tweezers for loading and unloading susceptors leads to a rapid formation of holes on the places where the SiC has been touched. Metallic residue, or particles will react with HCl and form a product that will react with the SiC.

CAUTION

To avoid pinholes development, use ultra pure ethanol to clean the substrate and tools you use to hold it.

13.5. OVER-ETCHING

Corrosion of the SiC only takes place during the HCl cleaning step. In the initial stage of the cleaning step, the whole susceptor is covered with Silicon. The recesses are covered with the silicon layer from the pre-coat step.

The first part of the SiC coating that becomes exposed is the wafer recess. During the rest of the cleaning step, there is no layer of Si over the recess. This is why pinholes are usually first observed in the recess.

Whenever there is silicon present on the susceptor, the HCl mixture will etch the silicon, forming silicon chlorides. Formation of these chlorides leads to a reaction equilibrium which means that the etch activity of HCl on silicon free parts is reduced. When over etching, pure HCl reacts strongly with the weak spots in the SiC coating. Reducing the over-etch time is essential in improving the lifetime of susceptors.

13.6. Prevention of pinholes by the user

13.6.1. Unpacking

- Take the susceptor in the sealed bag into the clean room.
- Carefully open, do not touch the susceptor with knife.
- Handle with plastic or rubber gloves.
- Do not place on a metal table! Use clean room wipes/tissues.
- Make sure not to touch metal parts of the reactor when installing the susceptor.

13.6.2. General

After a reactor has just been installed, there is a high risk of contamination. **We recommend to use a spare or already used susceptor during start-up and tune-in. Qualiflow Therm can provide it as an option**. This susceptor will catch the initial contamination. A new susceptor can be used to qualify low resistivity processes and start production.

We recommend also using an old susceptor after a **major modification** on the reactor has been done.

13.7. Temperature gradients

The SiC coated graphite susceptors and covers are sensitive to temperature gradients. These parts should not be used with temperature ramp rates over 50°C/s. The user must be aware that the gas injection (especially from reactor bottom side in some JetFirst systems) can lead to high temperature gradient and breakage in susceptor and cover. Qualiflow Therm strongly recommends using small gas flow for processes with susceptor especially if temperature exceeds 600°C. Qualiflow Therm will not give any warrantee on the susceptor and covers.

13.8. Conclusion

Pinhole formation is the predominant cause of susceptor failure. The main cause is metal contamination in the graphite or from the outside of the susceptor, as metals cause pinhole formation. The lifetime of susceptors can be extended by preventing any kind of metal contamination of the SiC coating. Careful handling will extend the lifetime of the susceptors.

Contact Qualiflow Therm for further information.

13.9. Use of susceptors in process atmosphere

Uncoated graphite:

- In reducing atmosphere (H_2): up to 2500°C;
- In oxidizing atmosphere: up to 400°C.

SiC coated graphite:

- In reducing or inert atmosphere: up to 1600°C;
- In oxidizing atmosphere: up to 1800°C.

CHAPTER 14. APPENDIX

14.1. Figure 1 Reactor Overview

14.2. Figure 2 Front Face and Rear Utility Panel

14.3. Figure 3 Dimensions & Footprint

14.4. Figure 4 Gas Circuit

14.5. Figure 5 Standard Vacuum circuit

14.6. Figure 6 Vacuum circuit with Pressure Controller

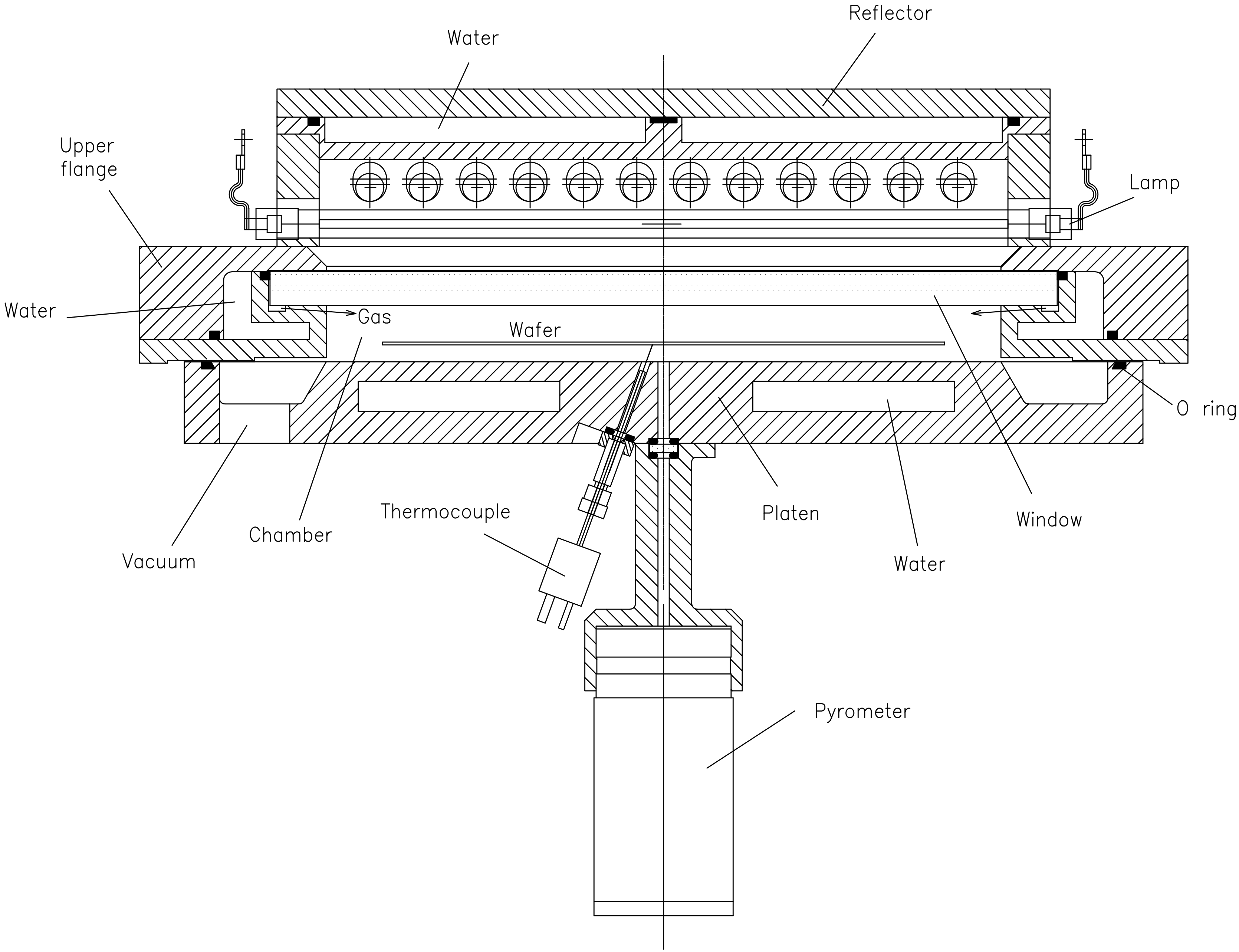
14.7. Figure 7 Vacuum circuit with Turbo Pump

14.8. Figure 8 Water circuit

14.9. Figure 9 Pneumatic circuit

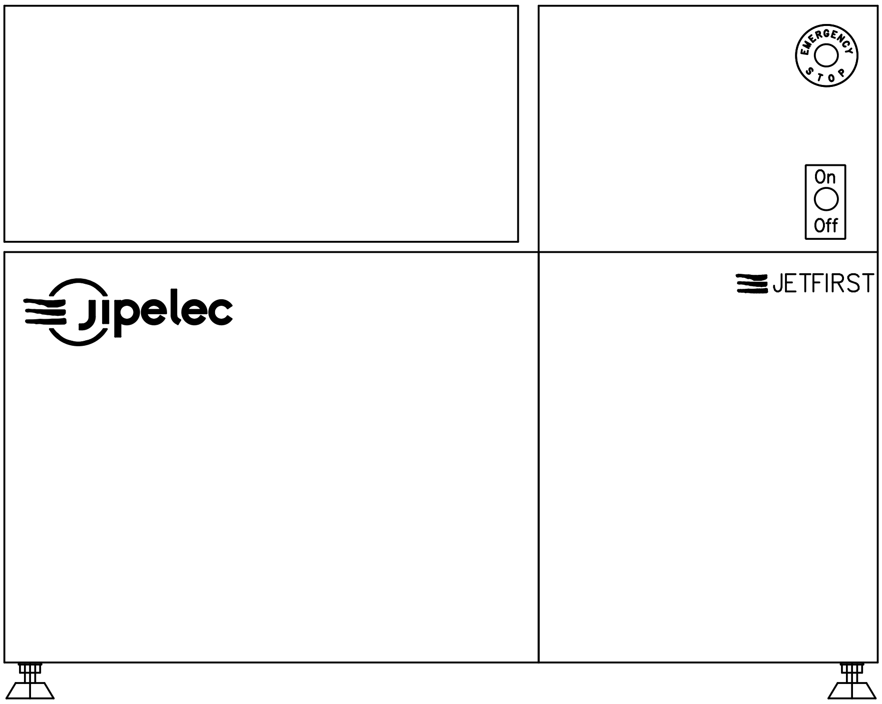
14.10. Figure 10 Thermocouple & Pyrometer Location

14.11. Figure 11 Quartz Pins Installation

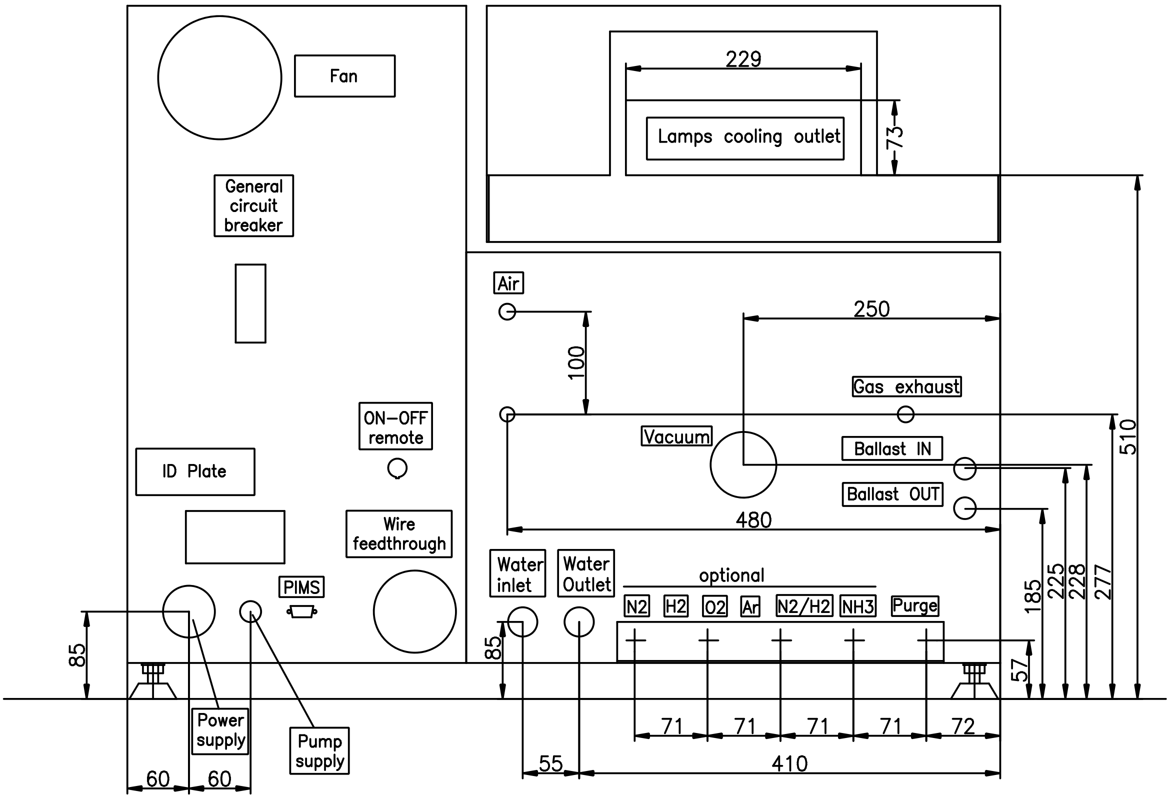


REACTOR OVERVIEW 200C	Fig. 1 JF200C
jipelec	V3

Front View



Rear View

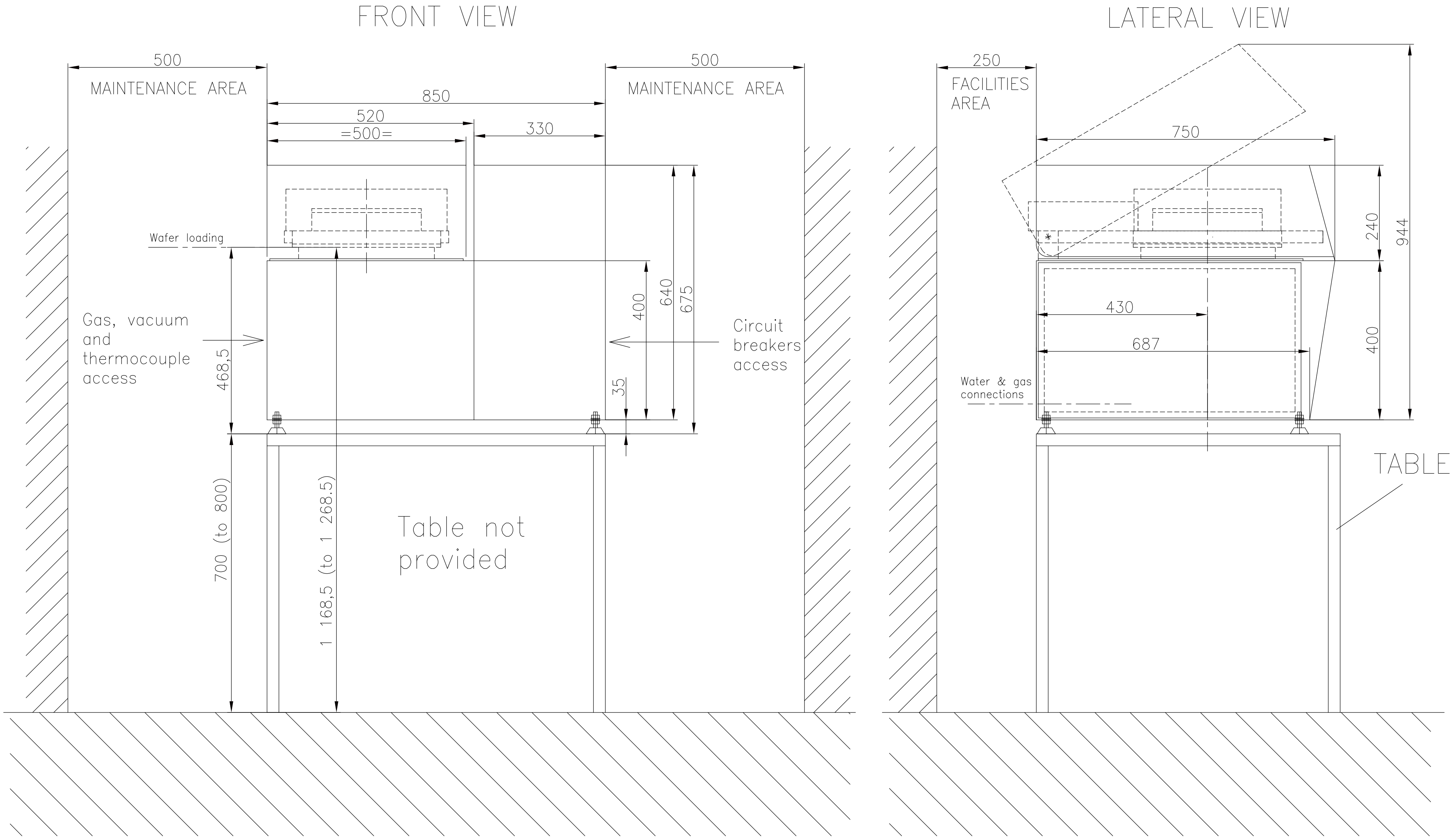


FRONT& REAR FACE

Fig. 2

JF100-200C

V4

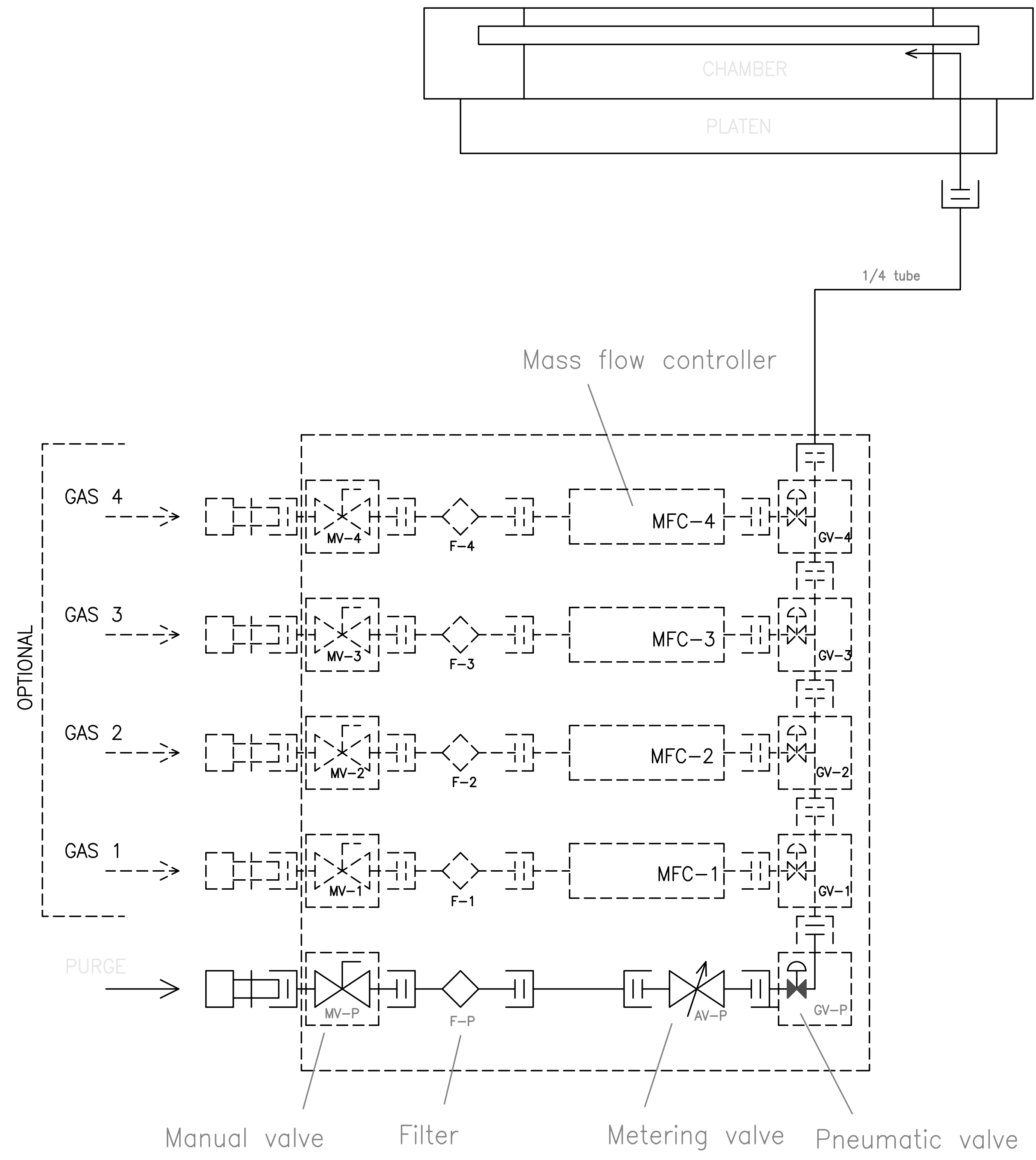


FOOT PRINT

Fig. 3

JF100–200C

jipelec

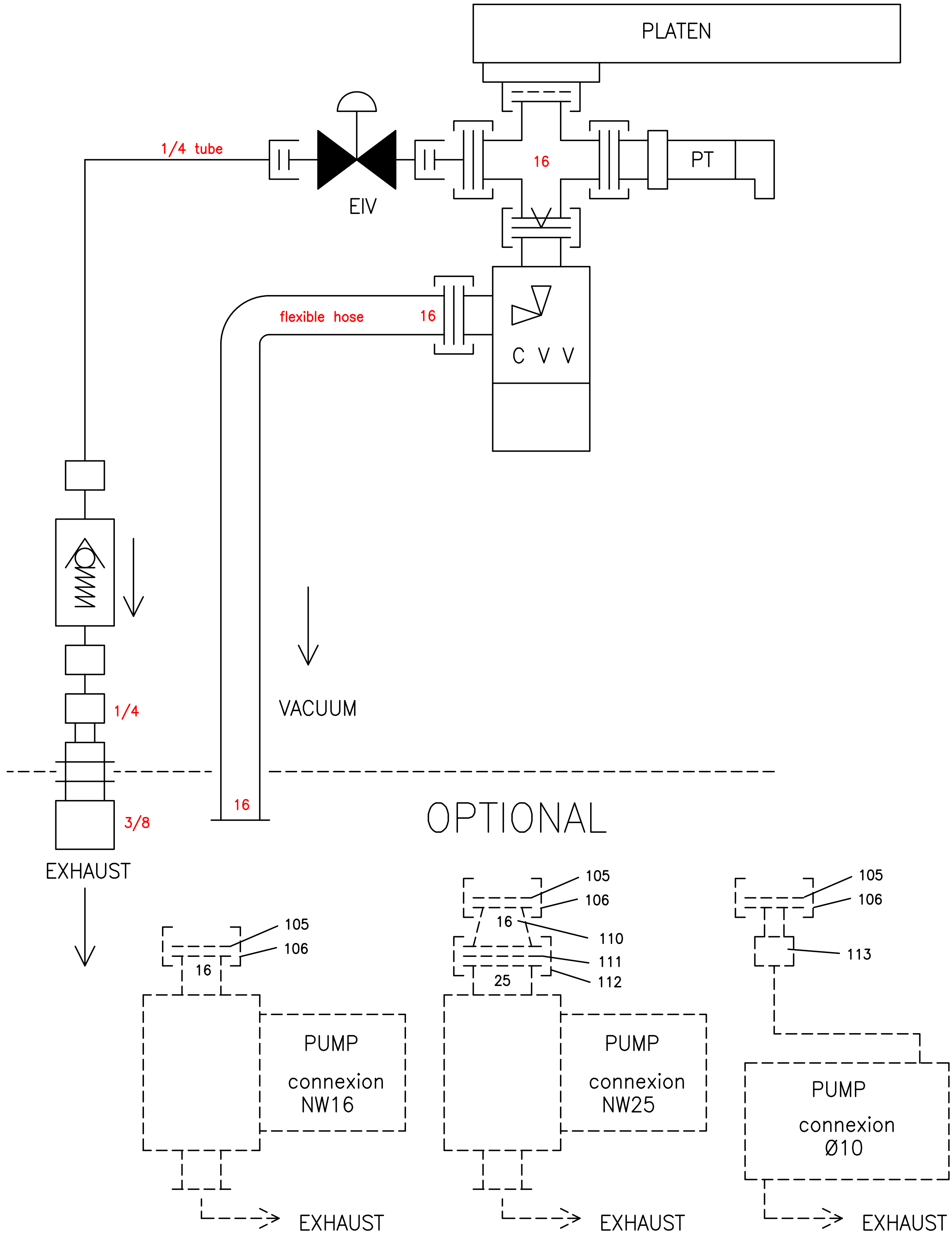


GAS CIRCUIT

Fig. 4

JF200C

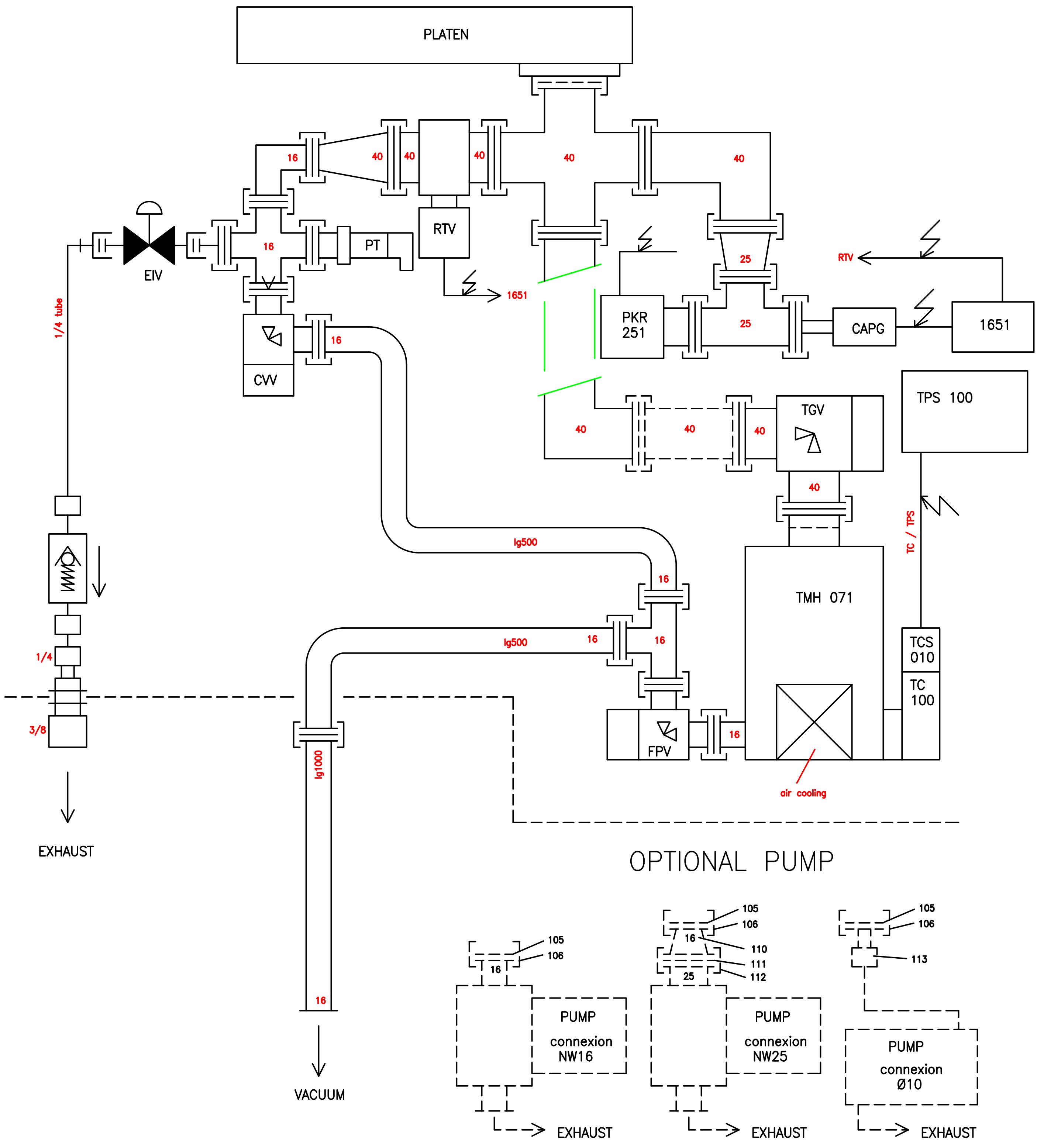
jipelec



VACUUM CIRCUIT

Fig. 5

JF200C

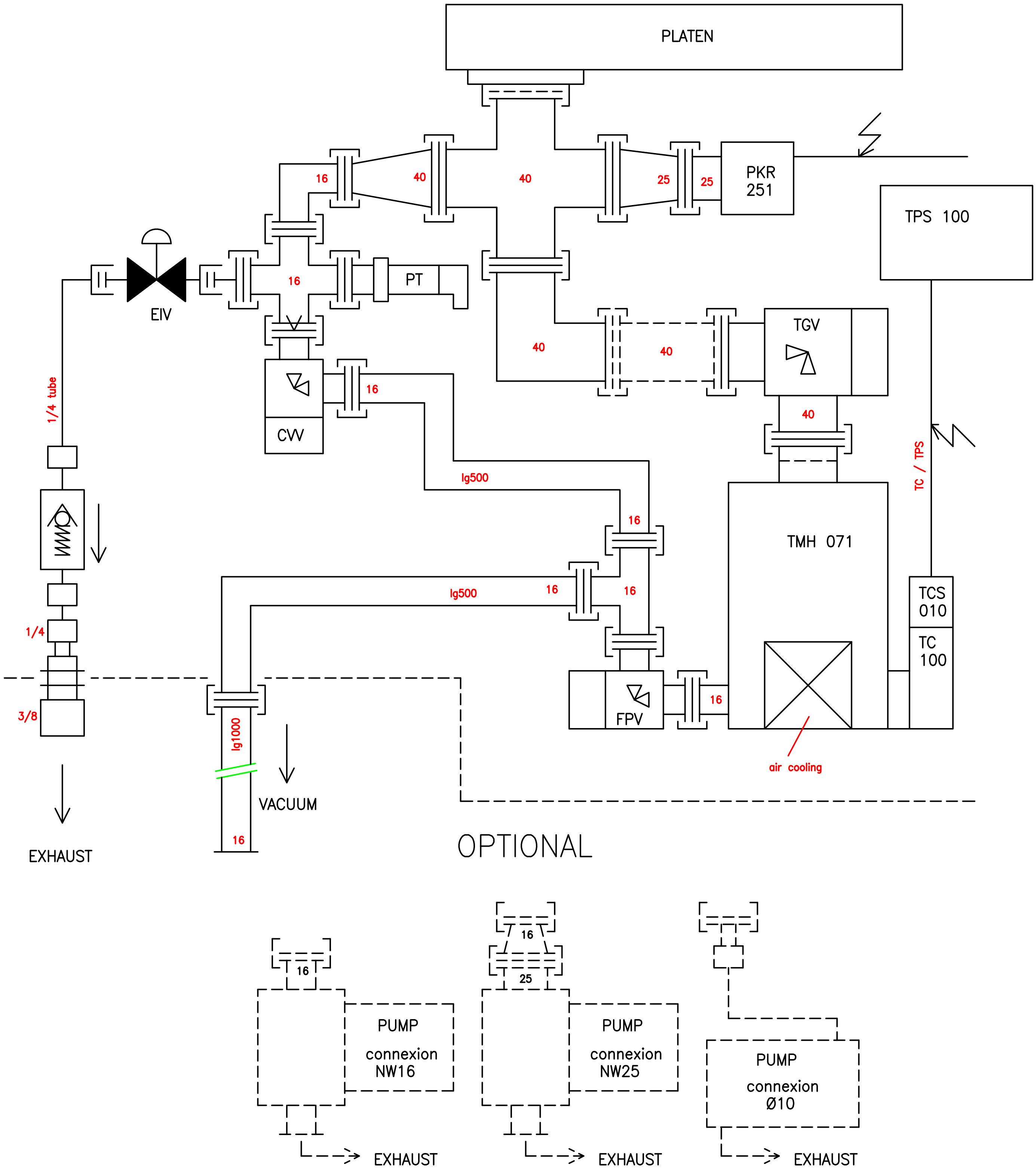


VACUUM CIRCUIT
WITH TURBO PUMP & PRESSURE CONTROL.

Fig. 6

JF200C

jipelec

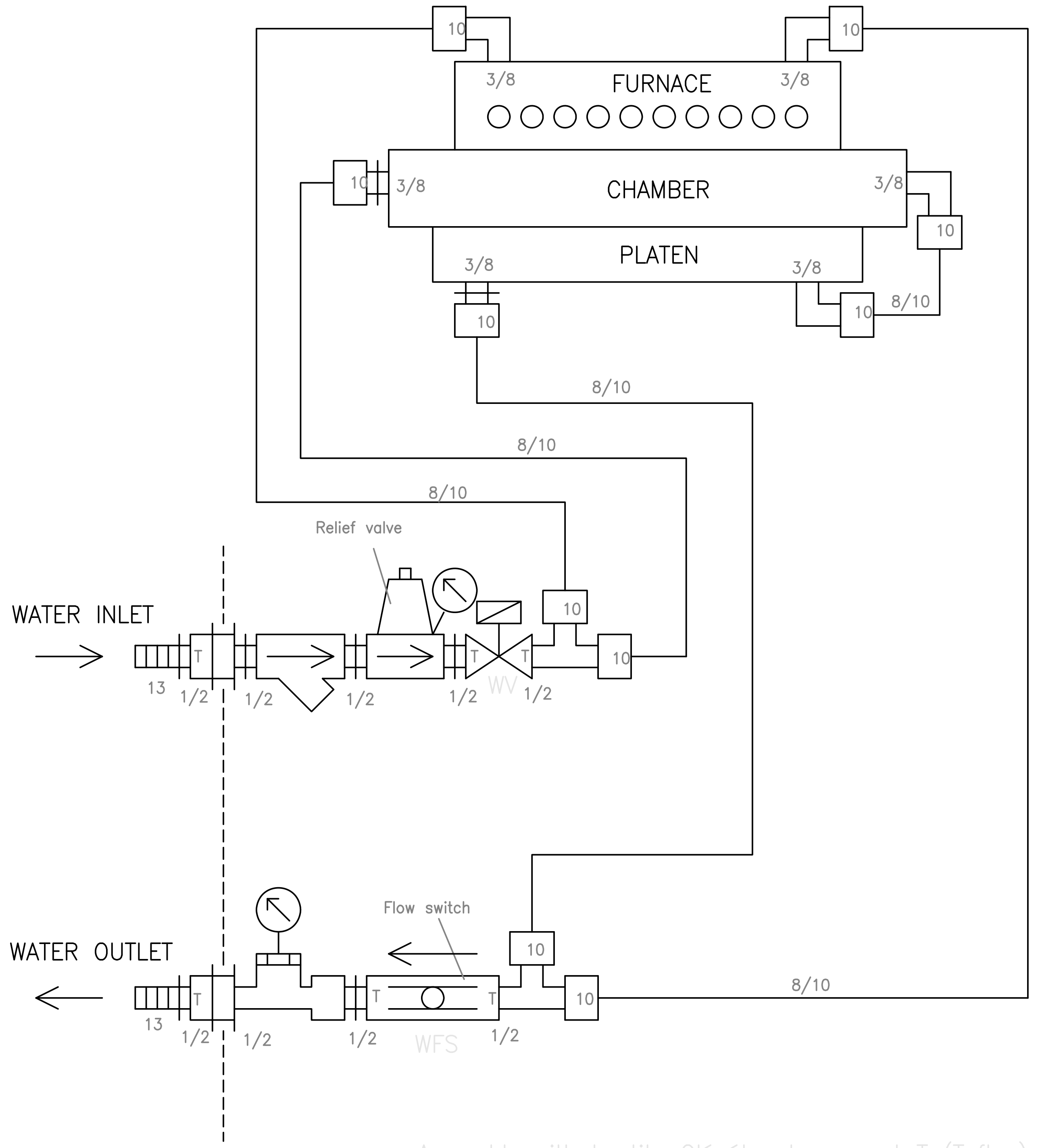


VACUUM CIRCUIT
WITH TURBO PUMP

Fig. 7

JF200C

jipelec



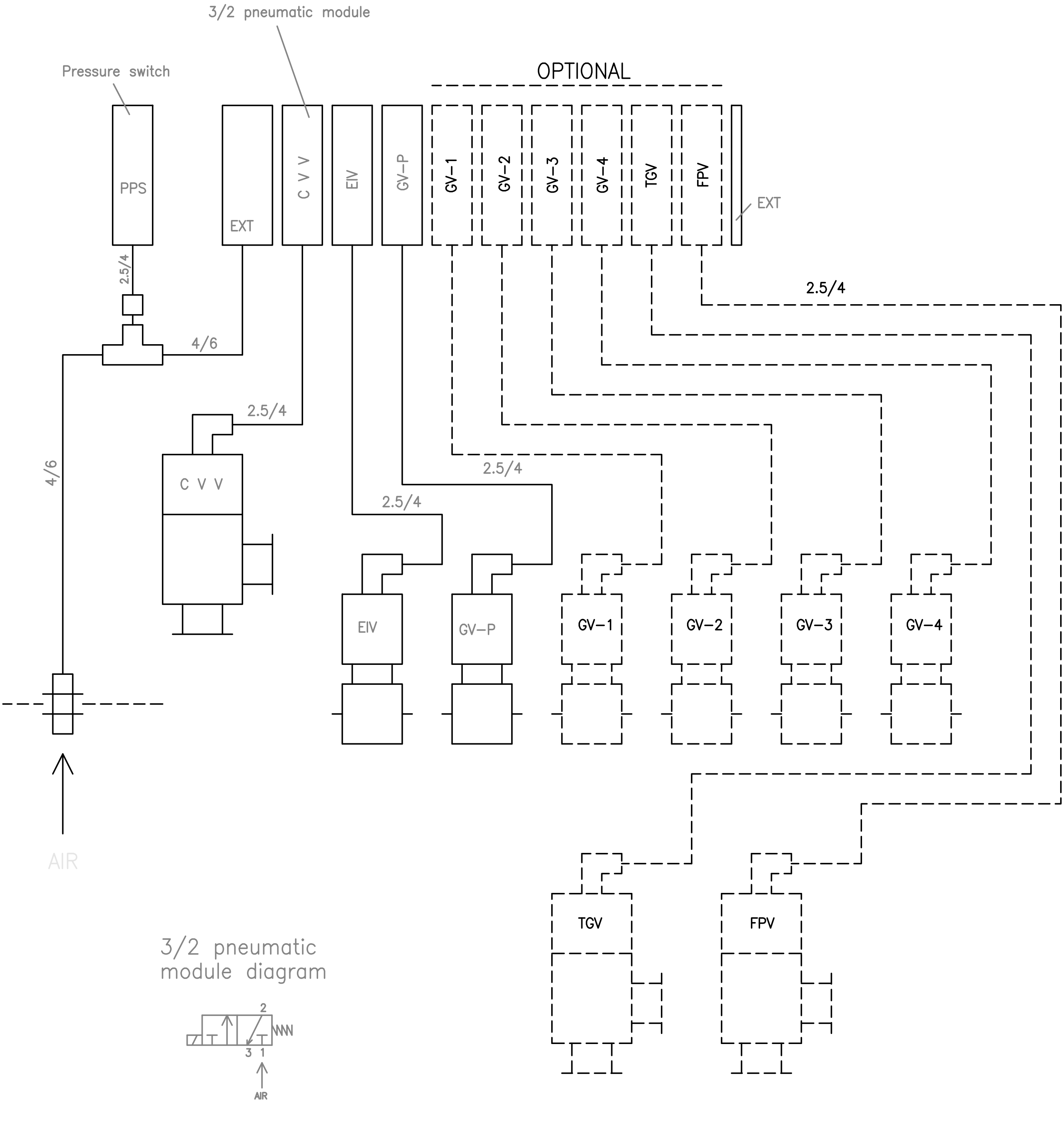
Assembly with Loctite Oléoétanche except T (Teflon)

WATER CIRCUIT

Fig. 8

JF200C

jipelec

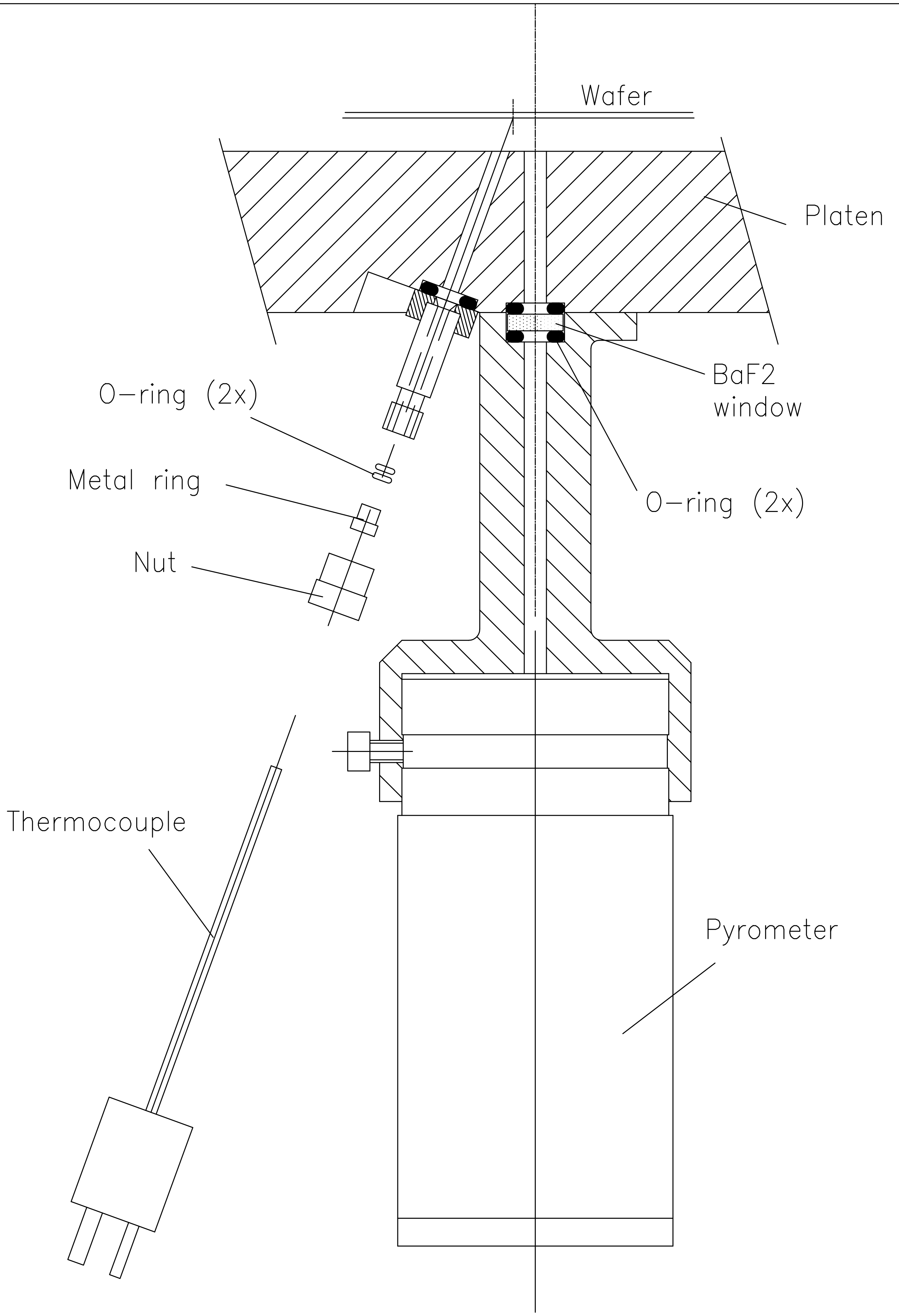


PNEUMATIC CIRCUIT

Fig. 9

JF200C

jipelec



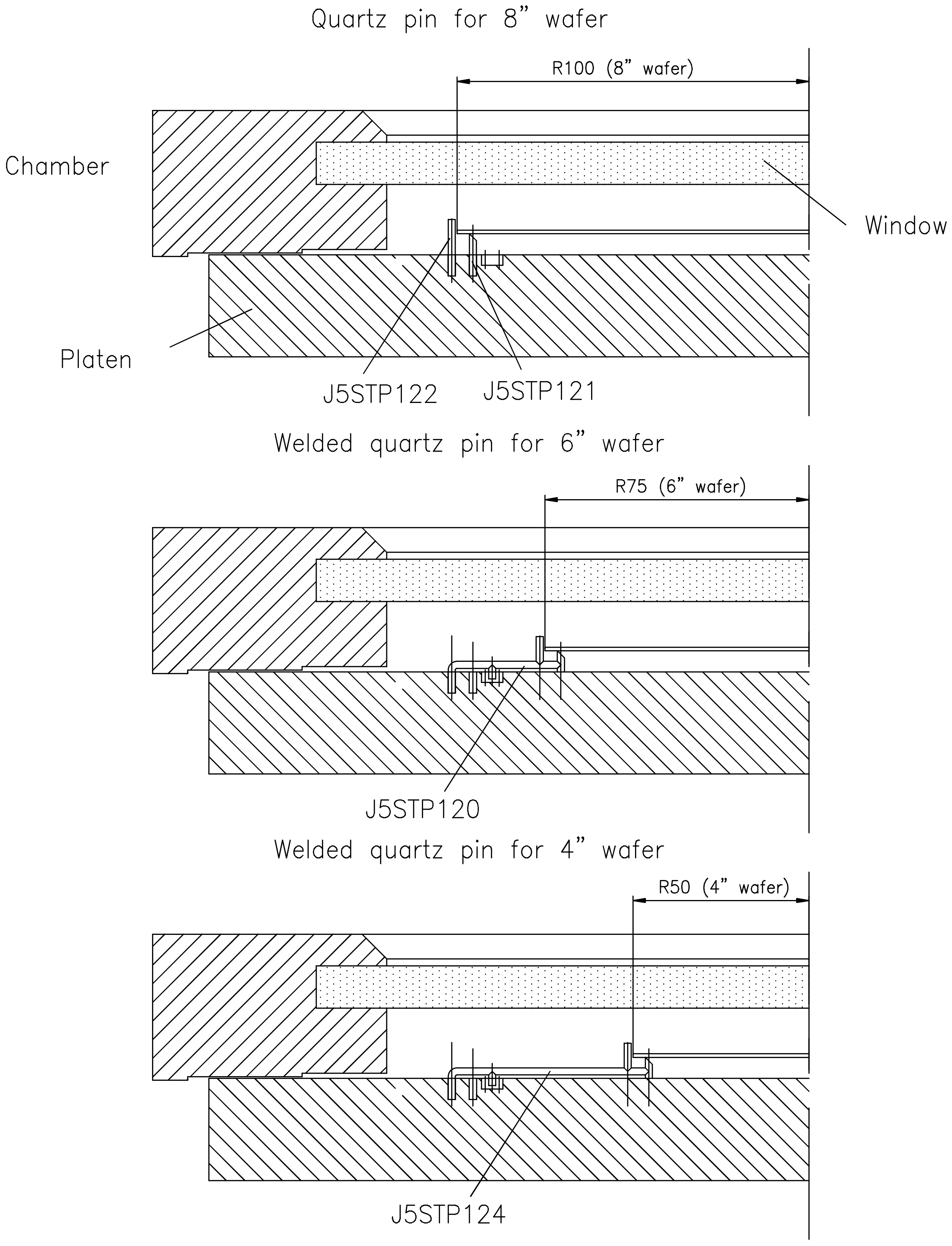
PYROMETER & THERMOCOUPLE

Fig. 10

JF100-200C

Jipelec

V3



QUARTZ PINS	Fig. 11
200C	JF200C
jipelec	V3