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General Description

Quotation No. 77578 V07

c.LAB 3.000-300-4(2)

In the following description options are also included. The exact scope of delivery is specified in section 1: **Prices and Commercial Terms**

The same numbering is used in the price overview and the description. Sub-items of a position are included in the scope of delivery, even if they are not listed separately.

Centrotherm reserves the right for technical changes and improvements, which do not affect the performance warrantees.

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0 General

- The system modules are:
  - Wafer loading area
  - Scavenger
  - Tube furnace
  - Gas system
  - Vacuum system
- The system is designed for wafer sizes up to 156mm x 156mm.
- Loading system: Softlanding
- If sub-systems (e.g. quartz ware, gas/vacuum system) are supplied by the customer, the process specifications have to be fixed in a separate agreement.

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0.1 System configuration

c.LAB 3.000-300-4(2)

Stack 4 (top):	**Empty**
Stack 3 :	
Process:	**Dry Oxidation**
Heater temperature:	600 - 1200°C
Process temperature:	700 - 1000°C
Process tube:	quartz
Loading system:	centrotherm Softlanding (SiC)
Tube closure type:	closed tube system
Stack 2:	
Process:	**Dry Oxidation**
Heater temperature:	600 - 1200°C
Process temperature:	700 - 1000°C
Process tube:	quartz
Loading system:	centrotherm Softlanding (SiC)
Tube closure type:	closed tube system
Stack 1:	**Empty**

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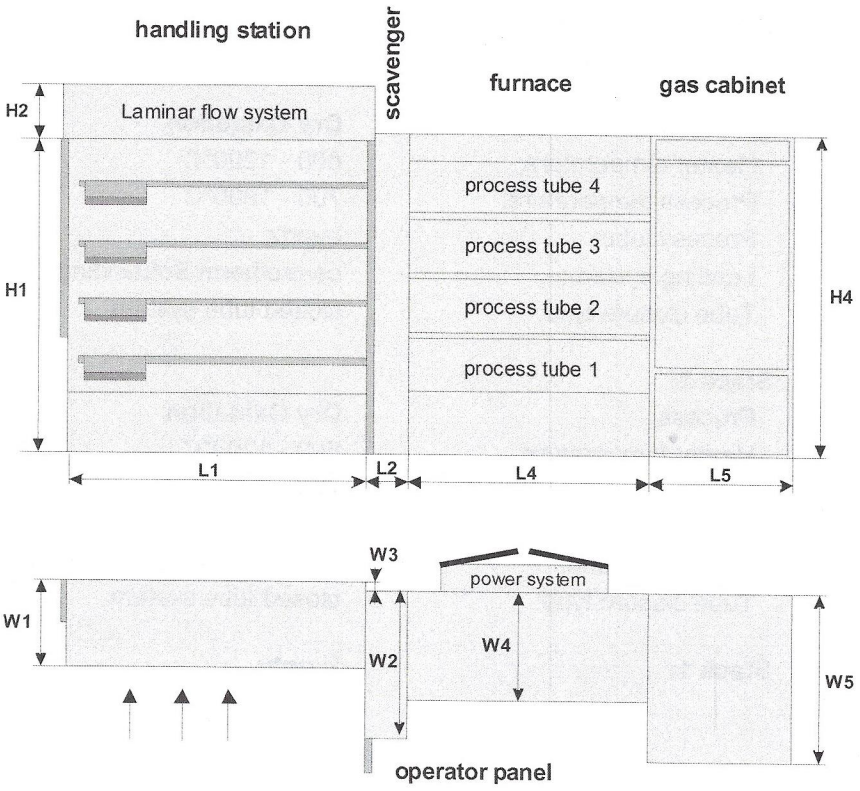
0.2 System dimensions - preliminary



L1:	3000 mm	W1:	650 mm	H1:	2680 mm
L2:	350 mm	W2:	1225 mm	H2:	320 mm
		W3:	145 mm		
L4:	2000 mm	W4:	800 mm	H4:	2650 mm
L5:	1200 mm	W5:	1400 mm		

1 Furnace

- The furnace subsystems are:
  - Heating elements
  - Temperature measurement system
  - Furnace control system
  - Furnace cooling system
  - Security system

1.1 Heating elements

- Temperature flat uniformity
  - 350-600°C: ±3,0°C
  - 600-1000°C: ±1,0°C
- Heating elements and configuration in centrotherm design
  - Excellent temperature uniformity
  - Excellent temperature stability
  - Extended lifetime
  - Adapted to the required dynamic properties (ramp rates, max. temperature) for optimized energy consumption

1.2 Temperature measurement

- Thermocouples
- for type and accuracy see section "Technical system configuration".
  - 2 Spike thermocouples in each heating zone
    - Temperature control directly connected (no compensation wiring) to DeviceNet measurement amplifier
    - Over-temperature protection
  - 1 profiling thermocouple in each heating zone (if cascade control is installed)
- Device-Net Thermocouple amplifier
  - Electronic cold junction reference (Pt 100)
  - No analog signals

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1.3 Furnace control system DeviceNet

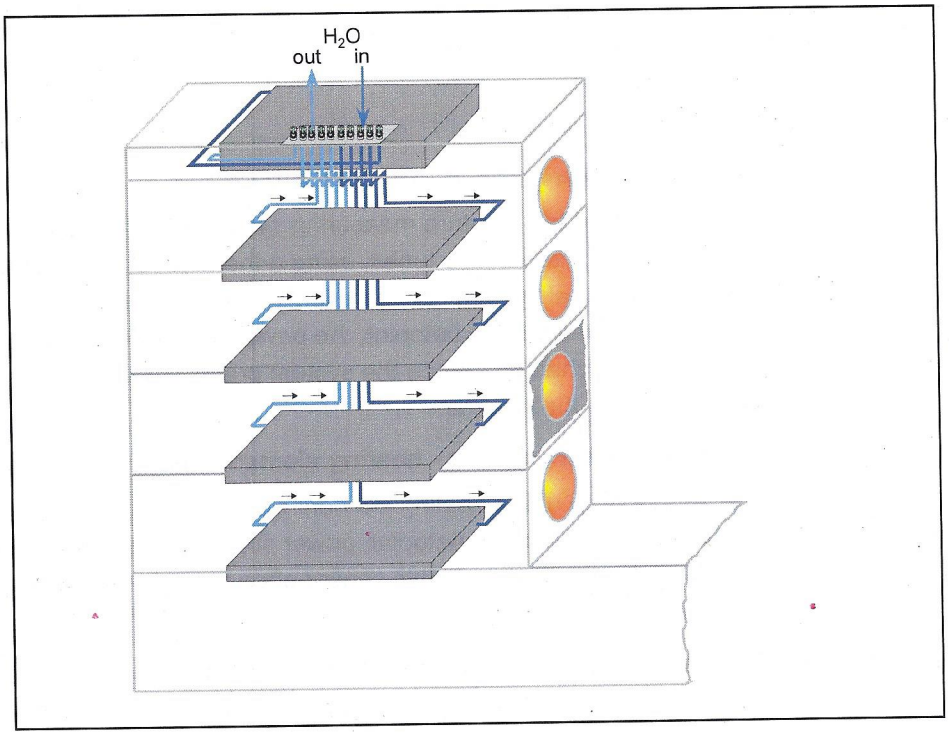
The system is equipped with a sensor-bus control system based on DeviceNet.

- Connected main components:
  - Temperature controller
    measurement and power unit
  - Gas-/vacuum system
    Valves, MFCs, pressure control
  - Loading machine
- Advantages
  - Digital transmission (no drift, no noise)
  - Remote service capability for all DeviceNet components
  - Continuous monitoring of all DeviceNet components
  - Reduced wiring (higher reliability)

1.4 Furnace Cooling system

The system is equipped with a closed cycle water cooling system.
Cooling air is not required.

For systems using heating elements with an inner diameter of 320 mm the coolers are replaced by direct cooled heating elements.



- Advantages:
  - No consumption of cleanroom air
  - No thermal interference between different tubes
  - No temperature rise in the furnace environment by hot air.
  - No contamination of the room by air movement (ventilation).
  - Low noise level.

1.5 Security systems CMS

Maximum security of the user, the process and the system is equipped with an independent centrotherm machine safety (CMS). The installed sensors supervise all the vital system functions and the CMS reacts in case of a failure independent of the tube computers. For easy fault location all error messages are displayed on the centrotherm machine interface (CMI), in plain text (English or German). Besides the standard set-up, numerous responses to a system failure can be programmed.

1.5.1 Basic systems

- **Over-temperature sensor - process tube**

  An independent temperature measuring system supervises the spike temperature of the process tubes, using a thermocouple (for type see section "Technical system configuration") for each heating zone. If the temperature exceeds the setpoint, the power supply of the heating element is switched off, hence the system prevents over-temperature and damage to the furnace.

- **Over-temperature sensor - heating element case**

  The temperature of the heating element case is supervised. If temperature exceeds the setpoint, power supply of the heating element is shut off. The activation of this sensor often indicates a low cooling water flow.

- **Over-temperature sensor - power electronics**

  The temperatures of transformers and thyristor modules are supervised. An over-temperature activates an alarm.

- **Water leakage sensor**

  Water leakage activates an alarm.

1.5.2 Additional systems for Oxidation (Hydrox)

- **Temperature supervision**

  The temperature of external torch system is measured. If temperature falls below the safety level (700°C), H_2 flow is switched off and an alarm is activated.

- **Flame supervision**

  The burning flame is checked by the hydrogen spectral line. If no flame can be detected after 20 sec an alarm is activated and the hydrogen flow is interrupted.

- **Flow ratio supervision**

  To prevent an oxygen depletion, actual O_2/H_2 flow ratio is supervised.

1.5.3 Additional systems for vacuum processes

- **Door supervision**

  A microswitch is actuated, if the door reaches the closed position. Only in this case, the vacuum- and process gas valves can be opened.

- **Pump purge flow supervision (rotary pumps only)**

  If rotary pumps are installed, the N_2 pump purge flow is measured by rotameters. The process gas valves are closed, if the purge flow drops below the setpoint.
  Dry pumps have an integrated purge flow control.

- **Exhaust tubing purge flow supervision (rotary pump only)**

  The N_2 purge flow into the exhaust tubing is controlled by a rotameter. The process gas valves are closed, if the purge flow drops below the setpoint.

- **Process pressure supervision**

  If the pressure in the process tube rises above 2.5 mbar (5 mbar), the process gas valves are closed. They can only be reopened, after the pressure has dropped below this setpoint.

- **Setpoint softpump**

  If the pressure in the process tube is above 5 mbar (10mbar), the pumping speed is reduced, to avoid particle generation.

- **Softvent**

  By using the two N_2-gas lines (MFC, metering valve) a soft vent function avoids particle generation.

- **Sensor for atmospheric pressure**

  During venting a sensor system compares the pressure inside and outside the process tube, to avoid over-pressure. An over-pressure valve is actuated, if necessary.

- **Over-pressure sensor 150mbar**

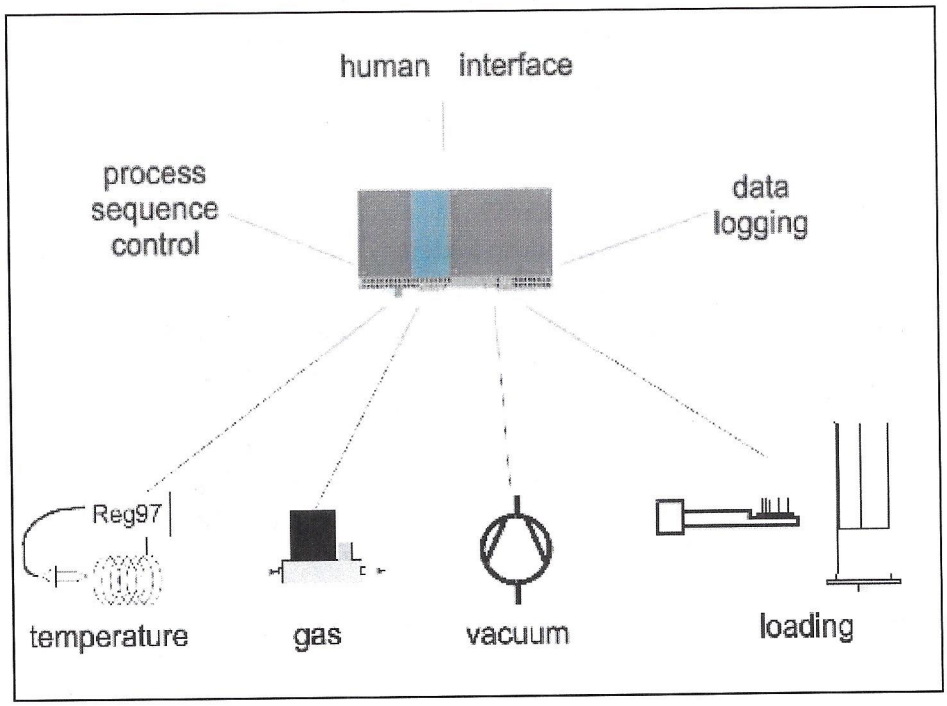
  If the over-pressure valve is actuated and the over-pressure in the process tube reaches 150 mbar, the gas flows are interrupted.

2 Process control system CCC

Principally the centrotherm furnaces can be integrated in a factory computer system. For solar cell applications a complete factory link is not usual, but all centrotherm tube furnaces (diffusion furnaces and plasma-CVD-furnaces) will be linked to a master computer. For data transfer "Ethernet" is used. A master computer is part of the diffusion system.

If not indicated otherwise, the software and manuals are supplied in English language.

2.1 CESAR - control computer



Each system is equipped with a control computer model CESAR including the CESAR-software. The control computer, an industrial PC, is independent of the Host-computer system. The control computer ie equipped with a field bus (CAN)-interface, HDD and a set of operation control systems (watchdog, over-temperature, etc.). The user interface for the tube computers and the handling computer of one furnace is a central color graphic, touch screen display.

The tube computer has the following features and functions.

- **Features**
  - programming language (similar PASCAL)
  - Simple programming
  - Easy program structure
  - Subroutine libraries
  - Data-Link-Variables for the on-line input of process parameters supplied by the Host-computer.
  - Different access levels (9 layers)
- **Functions**
  - Recipe generation and modification.
    - Storage capacity > 10.000 recipes
    - Unlimited number of command lines
  - Controlling of:
    - Temperature controller
    - Gas system
    - Loading system
    - Wafer handling system
  - Programmable Alarm and Abort levels
  - Automatic profiling during cascade-control even in a running process.
  - Unlimited data logging of user defined process data (Harddisk, NFS-Server-PC).
  - Ethernet interface board and software license (NFS-Client-Kit).
  - For systems with more than 2 process tubes: Ethernet wiring inside the system up to a 8 port Hub using 10-Base-T cable.

2.2 Cell controller system CCC-RM

2.2.1 Recipe organization

Die recipe organization composed of:

- Automatic recipe backup on a network server
- Assignment of recipes to tubes
- Recipe version control
- ASCII Export / Import of CESAR recipes
- Defining and modifying of recipes

2.2.2 ProtGraf - CESAR protocol analysis

Factory license for the software package ProtGraf. ProtGraf is the data analysis program for the process data generated by the tube computers (during recipe or in standby).

The program has the following functions:

- Data extraction
  This module converts the process protocol into an Excel compatible chart.
- Graphic display of process data
  This Excel like module displays the data (temperature, gas flow, boat position, etc.) for a selected process sequence or time interval.
- Tabular display of process data
  This module displays the process protocol for a selected process sequence or time interval. For the display data groups (alarm, setpoints, operator or system entries) can be selected.

2.2.3 Remote control program

Factory license for the remote control program of the tube computer. It allows to remote control a selected process tube from every computer connected to the Ethernet of the furnace system. Via remote control all functions of the tube computer are accessible.

2.2.4 Maintenance manager

- Scheduling of maintenance
- Control of maintenance intervals
- Maintenance history

2.3 CCC - PC

The process control system CCC (**C**entrotherm **C**ell **C**ontrol) is based on a PC or workstation, which is connected to the tube and the Host computer via Ethernet. This network allows the data transfer between one or more cell controller(s) and all tube computers. The application of the standard interface Ethernet makes the system easy to integrate into a variety of infrastructures. The cell controller(s) can be located in the clean room, in the gray room area or in the office.

2.3.1 Control PC

The Control PC package contains all hardware components which are necessary to run the CCC software.

- 21.5" TFT color display
- 500 GB HDD
- DVD-R/W drive
- Backup of the whole system
  (1:1 image backup of the HDD).
  - Backup of data, recipe and protocol files.
  - Medium for installation of updates.
- Keyboard and mouse
- Ethernet-Interface-board
- Software license for Windows 7

2.3.2 NAS Server

Recommended for installations of more than 10 machines.

- Linux-based
- Runs independently from control PC
- RAID 10 storage on 4 long-living hard disks
- Hot-swap, hot spare

2.3.3 Access for remote service

For remote service purposes an analogue, ADSL modem or internet access is installed, depending on the phone system. Via this modem connection, remote service of the tube computer and cell controller can be done by our software department or other authorized people.

2.4 Uninterruptible power supply (UPS) - option

The uninterruptible power supply UPS keeps the system running during power failure. By installing the UPS the following subsystems are independent of the stability of the main power supply:

- Tube computer
- Gas supply system
- Loading system

3 Temperature control system

3.1 Temperature controller REG 97

- Digital temperature control (Fuzzy enhanced PID)
- In-situ Profiling
- Model based ramp control
- Enhanced recovery behavior
- Measurement resolution
  - Temperature resolution: ±0,1 °C
  - Setpoint resolution: ±0,1 °C
  - Temperature accuracy: ±0,25 °C

3.2 Profiling elements

The profiling element consists of one thermocouple in each heating zone. Thermocouple type and accuracy see section "Technical system configuration".

3.3 Cascade temperature control with in situ profiling

The cascade temperature control system uses in addition to the spike thermocouples build-in profiling thermocouples. This allows the measurement of the real temperature in the tube during processing. To optimize the system response, the temperature control in each zone is done by two PID-controllers connected in series. This set-up has the following advantages.

- Short response time
- Well defined temperature ramping
- Better process stability
- Dynamic response independent of the batch size
- In situ profiling during selectable process steps. No time consuming, separate profiling run.

4 Scavenger

The gas exhaust system in the area of the tube closure is constructed as rectangular stainless steel chamber. Each chamber exhaust is connected to the main exhaust channel. The exhaust capacity may be adjusted separately for each chamber by a slide-valve. In vacuum and Closed Tube systems the scavenger has only emergency and cooling functions.

5 Boat handling system

5.1 Handling station configuration

5.1.1 Standard boat handling station

In the standard setup the loading station is open to the surrounding cleanroom.

5.2 Tube loading system

The automatic tube loading system may be configured for Softlanding or Cantilever operation. The Softlanding configuration can be used in Cantilever mode without mechanical modifications.
Main features of the system are:

- Control
  - Device-Net
  - Free programmable position and speed (linear motion).
  - Storage of paddle position during power failure by a synchronous driven reference.
- Easy, smooth linear motion by
  - Two parallel, multi supported guideways
  - Toothed-belt
  - DC-motor driven
- Stable up-down motion by
  - Synchronous toothed-belt drive of loading machine.
- A built-in electromagnetic slipping clutch
  - Allows the manual movement of the paddle during power failure or service.
  - Prevents system damage in case of blockage
- The machines are isolated from the laminar flow area by polished stainless steel sheets.

6 Tube closure systems

6.1 Automatic tube closure (Softlanding)

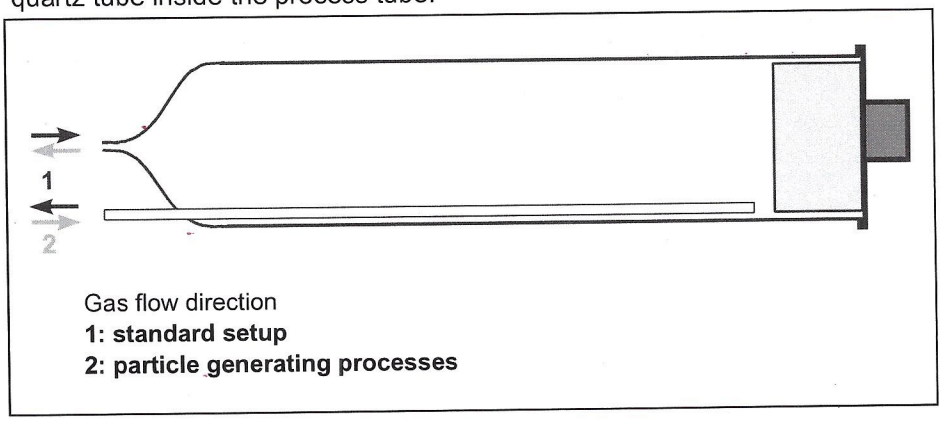
The automatic tube closure mechanism is based on a compressed air activated system.

6.1.1 Atmospheric processes (closed tube with back side exhaust)

The centrotherm Closed Tube System was developed for atmospheric processes, causing reactive or toxic exhausts which have to be treated. The system is highly recommended for the following standard processes:

- $POCl_3$ - Doping
- Wet Oxidation using HCl, TCA or TransLC
- Paper diffusion

If the centrotherm Closed Tube System is established, the process tube is closed by a door with an insulating quartz stopper. The quartz stopper closes the tube gastight. The exhaust is drawn off to the gas cabinet by a small quartz tube inside the process tube.



Gas flow direction
1: standard setup
2: particle generating processes

6.1.2 Low pressure processes

The tube closure for low pressure processes consists of a water cooled stainless steel vacuum flange and a thermal insulated stainless steel door. PECVD-systems are equipped with a quartz-window in the door.

6.2 Backside flange

6.2.1 Low pressure processes (PECVD)

The process tube of the liner design is closed at the backside by a water cooled stainless steel vacuum flange and a stainless steel plate. In the plate 2 Ultratorr connections 12 mm ± 0,35 mm (1x gas injector, 1x profiling element), two RF-feedthroughs and a quartz window are integrated.

7 Gas system cabinet GVS

The gas system cabinet contains the gas handling and vacuum equipment for all stacks.

- Electrochemical polished (316L) stainless steel tubing.
- All fittings are VCR with VA sheet gaskets.
- All welding is orbital.
- Miniature weld fittings are used to avoid bending.
- The front side doors of the source gas cabinet are manufactured of shaded acrylic glass.
- Locks for the source gas cabinet doors. - optional
- Leak rate better than $3x10^{-8}$ l mbar/sec
- Assembly in a cleanroom environment class 100.
- Gas system for delivery filled with N_2

8 Gas/vacuum system

8.1 Description of the tube gas/vacuum systems

8.1.1 Anneal/DryOxidation

- Compressed air operated diaphragm valves
- Manual diaphragm stack shut-off valves
- MFC gas lines (digital control):

N_2	30 slm
O_2	15 slm

- Process gas inlet from gas cabinet side
- N_2 emergency purge line with metering valve (NO)

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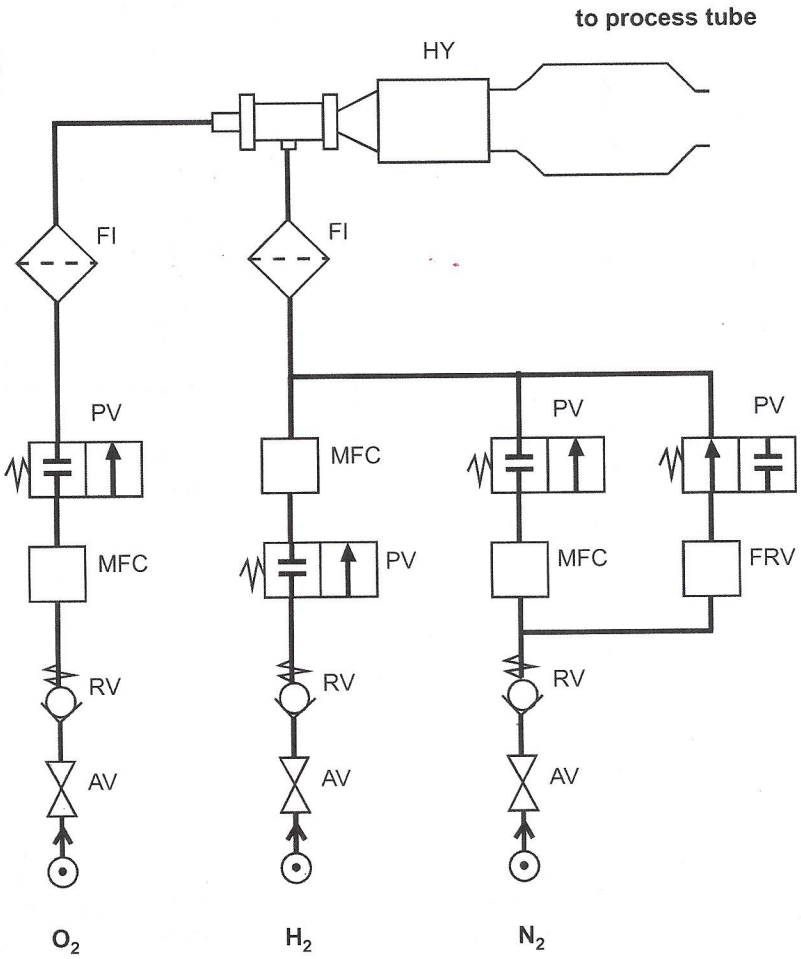
8.2 Sketches of the gas/vacuum systems

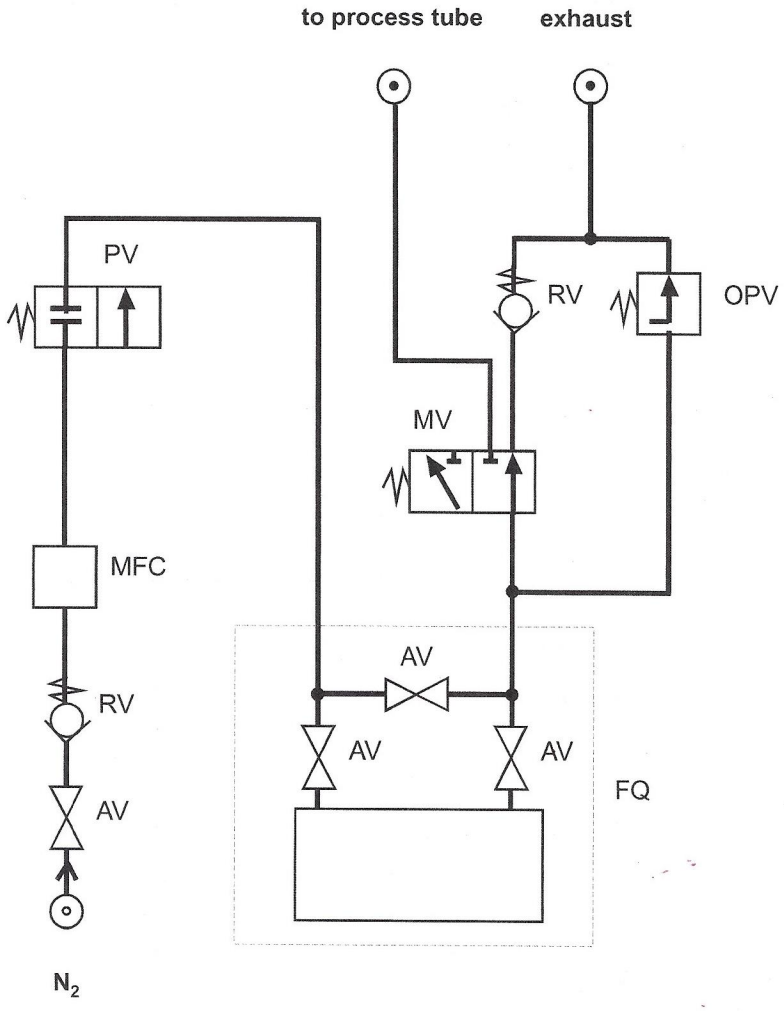
The following sketches are general outlines of the centrotherm systems. The scope of delivery for each stack is described in the section gas/vacuum systems.

8.2.1 Process tube gas supply lines (Hydrox)



PV:	**air operated valve**	**AV:**	**shut off valve**
MFC:	**mass flow controller**	**FI:**	**Filter**
FRV:	**metering valve**	**RV:**	**check valve**
HY:	**Hydrox burner**		

8.2.2 Process gas supply lines (bubbler)



PV:	**air operated valve**	**AV:**	**shut off valve**
MFC:	**mass flow controller**	**MV:**	**magnetic valve**
RV:	**check valve**	**OPV:**	**over pressure valve**
FQ:	**liquid source**		

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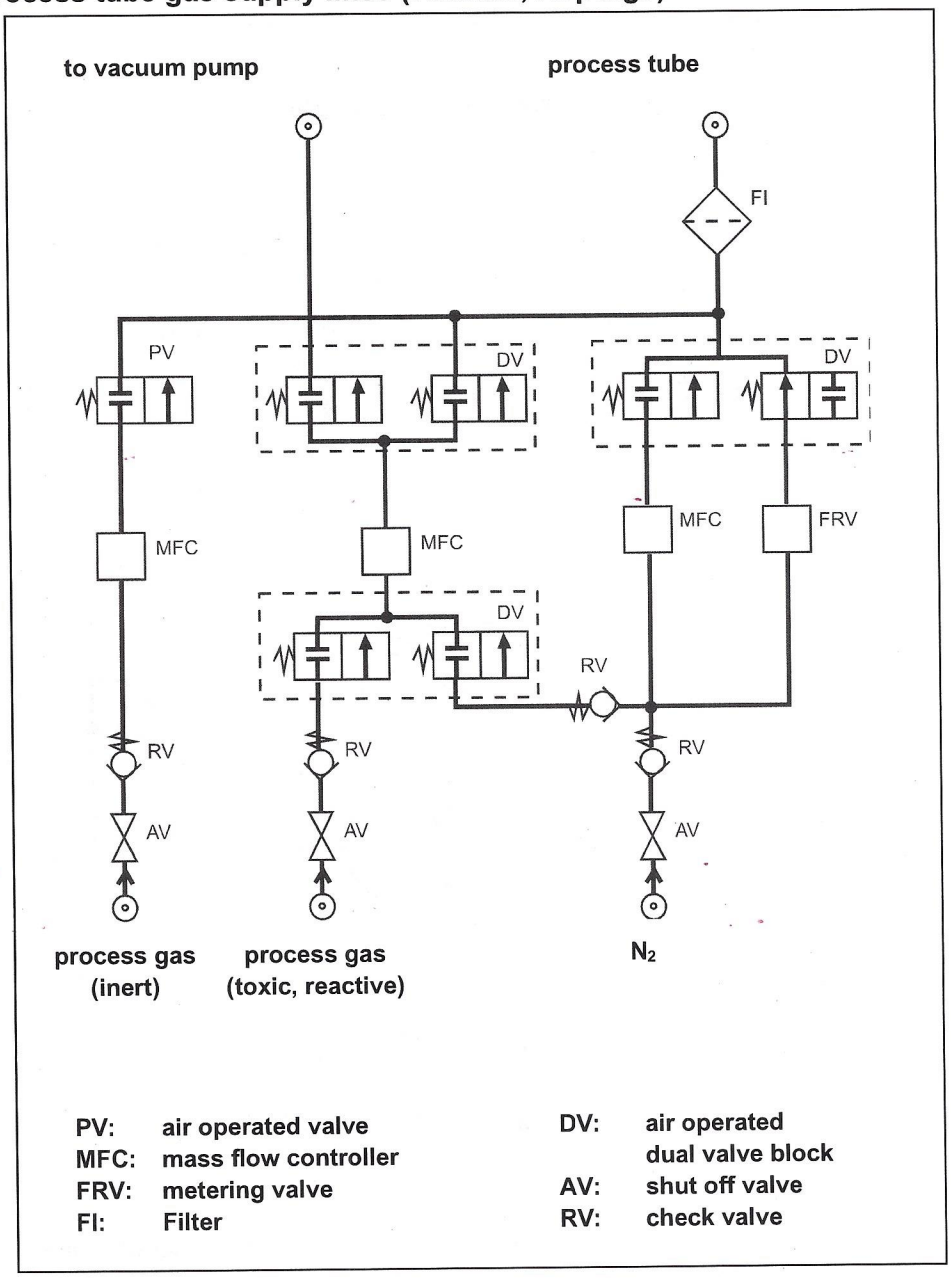
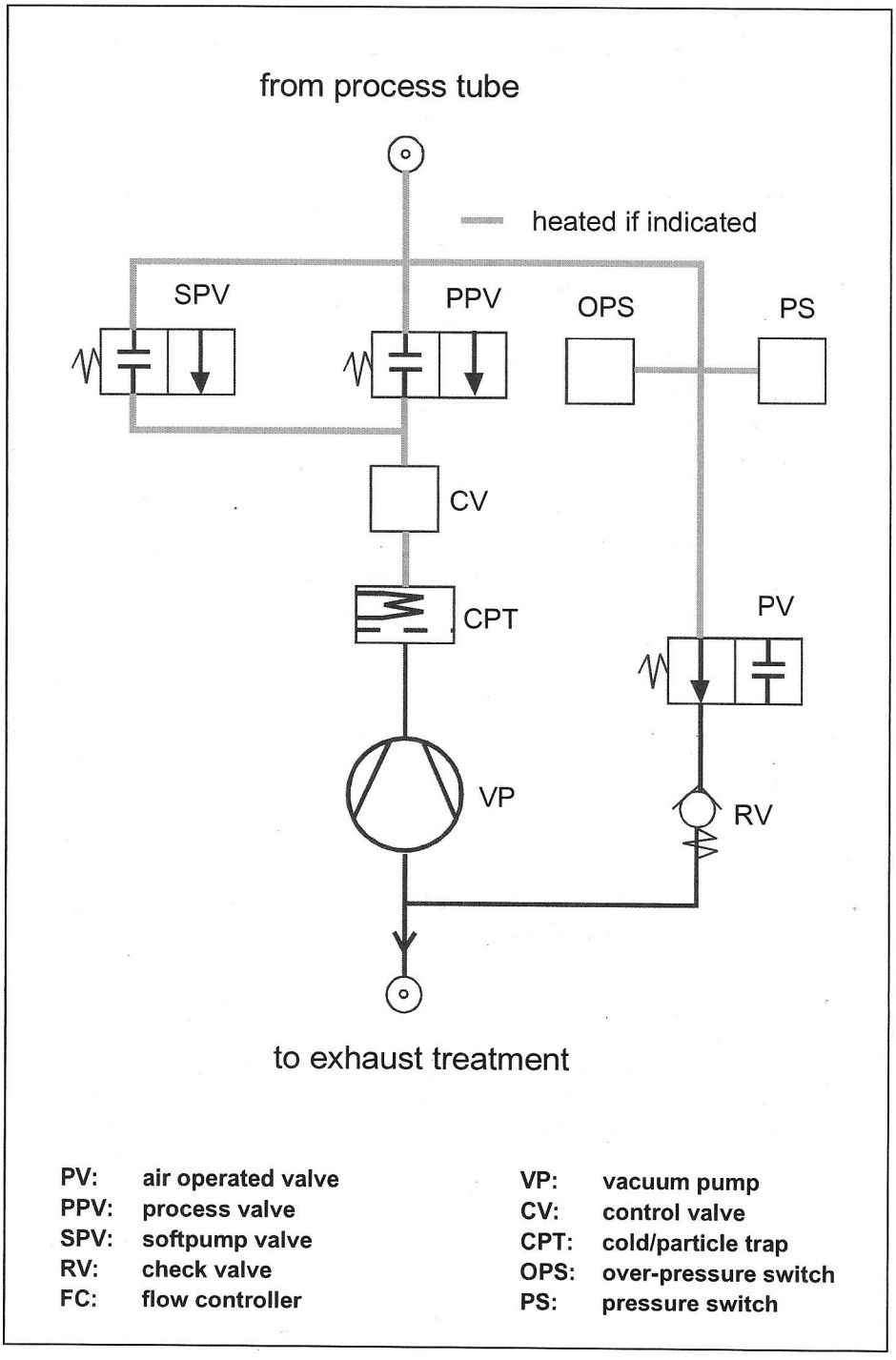
8.2.3 Process tube gas supply lines (vacuum, N_2 purge)



8.2.4 Vacuum system (each stack)



PV:	**air operated valve**	**VP:**	**vacuum pump**
PPV:	**process valve**	**CV:**	**control valve**
SPV:	**softpump valve**	**CPT:**	**cold/particle trap**
RV:	**check valve**	**OPS:**	**over-pressure switch**
FC:	**flow controller**	**PS:**	**pressure switch**

9 Plasma system

9.1 RF generator 40 kHz

The RF-power is supplied by an RF generator having the following features.

- max. RF output: 5 kW
- RF frequency: 40 kHz
- matching network
- pulsed RF output

10 Stack fittings

10.1 Process tubes

10.1.1 Quartz process tubes

- atmospheric processes
  - ID: 280 mm, AD: 290 mm
- vacuum processes
  - ID: 308 mm, AD: 316 mm

10.2 Loading paddles

10.2.1 SiC paddles

- standard SiC-Paddle (/Softlanding)

10.2.2 SiC rod paddles

- SiC-Rod-Paddle (Softlanding)

10.3 Process boats

10.3.1 Quartz boats (manual wafer loading)

- 8x open continuous boat
  25 slots, 4.76 mm spacing, 3° tilt
- Process boat carrier for 4 continuous boats

10.3.2 Quartz boats (automatic wafer loading)

- open longboat
  210 slots, 4.76 mm spacing, 3° tilt
  - 13 plates, 144 wafer (24 x 6)

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11 Training

11.1 Maintenance training

During the pre-acceptance test in Blaubeuren the maintenance training (service repair) takes place. This training gives the service staff the ability to diagnose a failure and repair it directly, or after an advise by telephone or remote access from the centrotherm service department.

11.2 System training

Scope of the system training is an introduction into the operation of furnace system and process control system (process programming, process protocol, recipe organization, standby functions, manual functions, etc.).
This training gives operators the ability to use the system in production environment.

11.3 Process training

The scope of the process training is operation of the system from the process point of view and development of customer designed processes.

This training will give process engineers the ability to administrate the system, write recipes, read process protocols, to diagnose failures and initiate appropriate steps.

Trainings beyond that are charged according actual costs. If you would like to receive a detailed offer please send your request to aftersales@centrotherm.de.

12 System requirements/configuration/data

12.1 Facility/utility requirements

The following supply requirements have to be met for a reliable operation of the equipment. They shall be provided by the customer as of move-in.

- Electrical supply
  - Max. power consumption (3 Phase, 5 wire, 400V): 25 KW/tube
  - Average power consumption 9 kW/tube
  - Type of load ohmic
- Process gas pressure:
  - N_2, NH_3 2,5-3,5 bar
  - SiH_4 1,5-2,5 bar
- Compressed air: 7-10 bar
  - max. short term flow per tube simultaneous operation tubes unlikely 20 slm
  - Consumption per tube and process < 30 slm
  - Pressure dew point: < -20 °C
  - Oil content: < 0.05 mg/m^3
- N_2-purge gas flow (each pump)
  - Dry pump unit (Ebara) 20 l min^{-1}
  - N_2 exhaust purge per pump (if no waste gas cleaning is used) 50 l min^{-1}
- Required exhaust system capacity
  - Scavenger (1 tube ∅ 160mm, if required 2 tubes ∅ 160mm): 200 m^{3}h^{-1}/tube
  - Gas cabinet case (tube ∅ 100/125mm): 100 m^{3}h^{-1}
  - Gas cabinet toxic gas (tube ∅ 100/125mm): 100 m^{3}h^{-1}

- Vacuum pump exhaust

  The vacuum pump exhaust contains:

  - during deposition a mixture of N_2 and the following reactive gases: SiH_4 (averg. 0.8slm, peak: 2.4slm), NH_3 (averg. 6slm, peak: 20slm and their reaction products).
  - during pump down N_2, O_2.

  On the facility side an appropriate treatment system has to be installed by the buyer, to guaranty a safe handling of this reactive exhaust gas mixture. The exhaust treatment system has to meet the local regulations and comply state of the art; the system must be certified by an authorized organization. Centrotherm shall not be liable for any damages in conjunction with the exhaust treatment. For safety reasons, the exhaust handling system has to supply a "no failure" signal to the PECVD system, otherwise the process gases cannot be switched on, this means no deposition can be run. Optional the furnace can be delivered with a N_2 dilution system, which reduces the reactive gas concentration in the exhaust to a safe level. (consumption: N_2: 150slm/tube)

- Cooling water

  - Differential pressure: 4 bar
  - Maximum system pressure: 10 bar
  - Temperature range: dew. point to 25 °C
  - Temperature raise delta T: 20 °C
  - Main heat exchanger flow: 10 l min^{-1}
  - Stack heat exchanger flow: 10 l min^{-1}/ tube
  - Dry pump unit flow each pump: (Ebara): 5-8 l min^{-1}

12.2 Technical system configuration

The system will be supplied with the following system configuration.
Required changes have to be specified with the order.

➢ Thermocouple	
• type	S (Pt-PtRh 10%)
• accuracy	0,1 %
➢ Control panel location (1. at scavenger integrated in the cleanroom wall, 2. at the loading port)	1
➢ Uninterrupted power supply (external, internal, non)	non
➢ Power distribution cabinet	
• on furnace backside	yes
➢ Pumps	
• external supply	yes
➢ Master computer system	
• Supplier of PC	as in scope
• Remote service access (ISDN or analogue)	ISDN
➢ Location of media supply	
• Electric:	from top
• Process gas, compressed air:	from top
• Vacuum:	from top
• Exhaust:	from top
• Cooling water:	from top
➢ Language	
• Software	English
• Documentation	English
• Labels:	English
➢ Color	
• Case:	RAL 9016 (white)
• Operator panel:	RAL 3002 (red)
➢ Transport	
• Disassembly of furnace or loading module necessary for transport:	no

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- Rasirc System Requirements

Environmental Conditions		0°-40° C 30% to 90% humidity, non-condensing Class 1000 cleanroom or tool cabinet Protection of the unit from water leaks from surrounding process equipment	
Water		Regulated and filtered to 0.1 µm at 1-1.3 barg (15-20 psig), 18 megaohm DI water. Not filtering voids warranty.	
CDA/N2		4.1-4.8 barg (60-70 psig) pressure requirement, filtered at 1 µm. Not filtering voids warranty.+	
Drain		Minimum 6mm (1/4") system drain line 100°C	
Power Requirement		102B10	102B15
02B	200-240 VAC	10A	10A
Power Requirement		200-240 VAC, 20A, single phase	
Fuse		Circuit Breaker, 200-240 VAC, 20A	

13 Silicon wafer specification

With the equipment and processes to be delivered, silicon solar cells can be made with the following As-Cut specification:

	multi-crystalline wafer	mono-crystalline wafer
1. electrical properties		
Specific resistivity	0.5 ohm cm to 2.5 ohm cm	0.5 ohm cm to 2.0 ohm cm
Minority carrier lifetime (µ-PCD, as cut)	Min. 1.8µs (measured on 240µm thick wafer)	Min. 2.5µs (measured on 240µm thick wafer)
2. Chemical properties		
Carbon concentration [Cs]	Max. $2x10^{18}$ atoms/cm^3	Max. $5x10^{17}$ atoms/cm^3
Oxygen concentration, [Oi]	Max. $8x10^{17}$ atoms/cm^3	Max. $9x10^{17}$ atoms/cm^3
3. Crystal properties		
Crystal structure	Multi-crystalline	Mono-crystalline
Crystal orientation	---	<100>
Crystal defects	No inclusions and holes visible with the naked eye	No inclusions and holes visible with the naked eye
4. Geometrical properties		
Shape of wafer	Squared	Quasi-squared
Length wafer edges	125.0mm+-0.5mm	125.0mm+-0.5mm Diagonal length: ≥ 165mm
	156.0mm+-0.5mm	156.0mm+-0.5mm Diagonal length: ≥ 195.0mm
Minimum square area covered (total deviation (size + angle))	124.0mm x 124.0mm 155.0mm x 155.0mm	-
Maximum square area covered (total deviation (size + angle))	126.0mm x 126.0mm 157.0mm x 157.0mm	126.0mm x 126.0mm 157.0mm x 157.0mm
Bevel edge width	2mm +- 0.5 (hypotenuse)	-
Bevel edge angle	45deg +- 10deg	-
Wafer thickness range	160-250µm 180-250µm[2)]	150-250µm 180-250µm[2)]
Average thickness range	Max. 50µm	Max. 50µm
TTV	Max. 20µm	Max. 20µm
Warpage	< 150µm	< 150µm
Mechanical stability	3N[1)]	3N[1)]
5. Appearance		
Edge chip	<5mm (length) x 0.5mm (depth), max. number: 3	<5mm (length) x 0.5mm (depth), max. number: 3
Crack and pin hole	No cracks and pinholes visible with the naked eye	No cracks and pinholes visible with the naked eye
Wafer surface	As cut and cleaned	As cut and cleaned
	No stains visible with naked eye	No stains visible with naked eye
Saw marks	Max. 10µm (depth)	Max. 10µm (depth)
Average grain size	> 25 mm	---
6. Statistical quality criteria	AQL 2.5 (for measured properties)	AQL 2.5 (for measured properties)
7. Crystal growth technique	Bridgman (or cast, etc.)	Czochralski

1) By Four-Point-Twisting test of the wafer. The wafer is held by two dowel pins, on 2 diagonal corners, while it is stressed by downward bending of the two unsupported corners.
2) Thickness range for the warranted performance data.