Thin Film Solutions Ltd
Innovation Delivered In Thin Films

PECVD P500 Plus

INSTRUCTION MANUAL

Revision A

- Thin Film Solutions Limited -
Block 7, Kelvin Campus, West of Scotland Science Park, Glasgow G20 0TH, United Kingdom
Tel: +44 (0) 1436 679433; Fax: +44 (0) 1436 640188
Web: www.thinfs.com Email: admin@thinfs.com

Prerelease Version

PECVD and MOCVD

Instruction Manual

CONTENTS

1.0 Basic Information

This manual provides essential technical information on the installation, operation and maintenance of the PECVD P500+ system. It is to be read in conjunction with the individual manuals provided by the manufacturers of the various sub-systems and components that are installed within the equipment.

IMPORTANT

Review the manufacturer's manual associated with any relevant sub-system (e.g. power supply, vacuum pump, etc.) before operating or servicing such equipment.

Within this manual Warnings and Cautions are given to draw attention to important operation practices. The meanings of these statements are explained below.

WARNING

A procedure or practice that could result in personal injury if not followed carefully.

CAUTION

A procedure or practice that could result in damage to the equipment if not followed carefully.

Your attention is drawn to the following warnings

WARNING

RF can cause serious burns or interference of sensitive electronic equipment, such as heart pacemakers. Do not operate the system unless all safety guidelines have been adhered to and all interlocks are in place.

WARNING

Hazardous and explosive gasses and residue maybe present in the chamber and the gas system. Ensure all precautions are taken before performing any operational or maintenance work on the system.

WARNING

RF operation can interfere with pacemakers, please check safety guidelines for recommended safe distances and operating conditions.

WARNING

Replace any damaged chamber windows immediately to minimise the potential implosion hazard.

WARNING

Coated components will be heated by the process. Ensure that an appropriate risk assessment is carried out before handling.

WARNING

It is important that all safety related interlocks are checked regularly to ensure their proper function. Any faults in these interlocks and their associated circuitry must be corrected immediately.

WARNING

The residues/by-products from the deposition of certain materials may constitute a hazard to health. Ensure that the relevant risks of each have been appropriately assessed.

WARNING

If any Viton™ fluoroelastomer seals are overheated, the decomposition products will include hydrofluoric acid.

WARNING

The high vacuum valves may operate without warning in the case of a power failure or loss of compressed air. Keep fingers and objects away from the opening of valves. Never touch moving parts.

1.1 **Equipment Description**

1.1.1 Overview

The PECVD P500+ system is designed for the sequential deposition of mechanical films by Plasma Enhanced Chemical Vapour Deposition (PECVD) with gas and/ or metal organic precursor feed to the main chamber.

The system comprises a welded stainless steel main vacuum chamber mounted on a frame with full pumping system and a control rack with power supplies.

Two 250mm retrofitable RF electrodes are mounted on the top and bottom base plates of the chamber and substrates can be placed on either of these with suitable jigs. The vacuum chamber is fitted with a vertical hoist system allowing access to both top and bottom electrodes.

Detailed description as follows.

1.1.2 Chamber, Lift Mechanism and Door Access

Chamber diameter is 500mm mounted onto a frame with lift mechanism as shown in Figure 1.

Note as an additional feature to prevent RF leakage the main chamber incorporates a dual seal arrangement to provide a continuous low impedance connection between the base and the chamber.

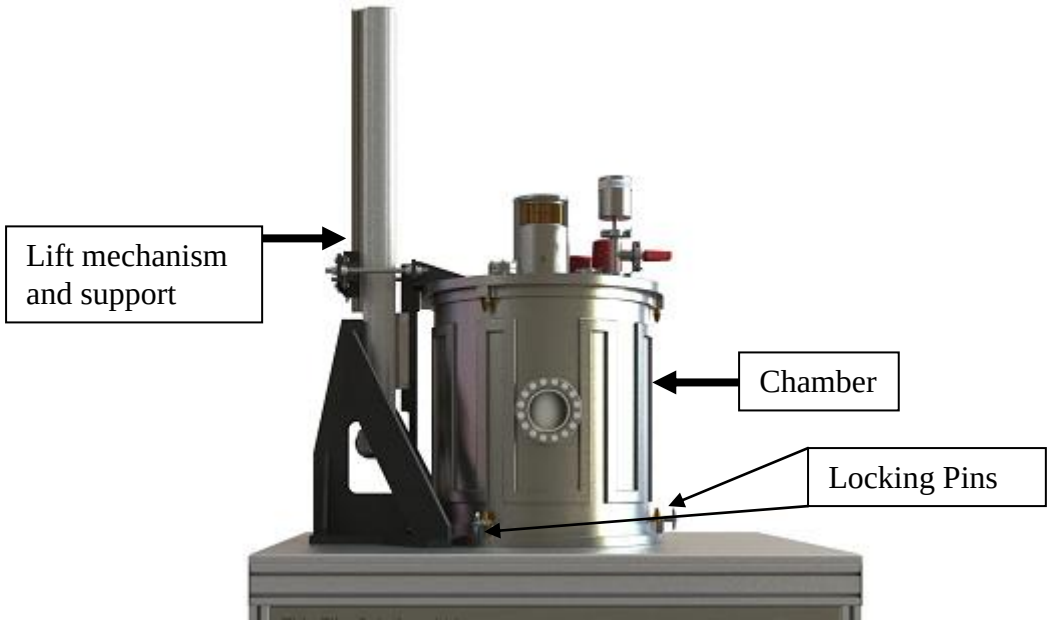
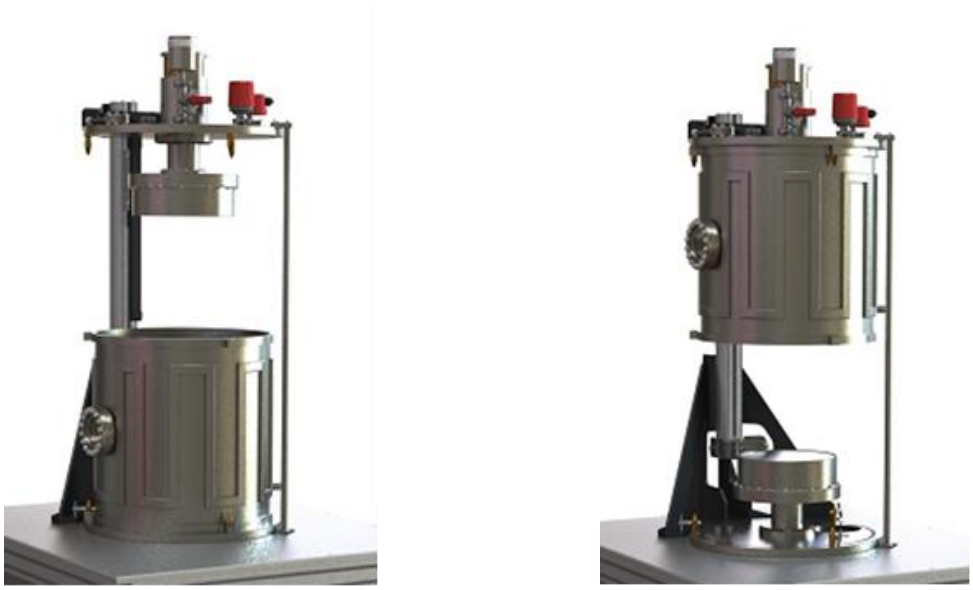


Figure 1 Stainless steel water cooled chamber with front viewport and hoist for lift of top plate/ electrode or chamber/ top plate

Locking pins (three off) are used to enable top plate or chamber/ top plate to be lifted as shown in figure 2a and b respectively. Locking pins are located at based of chamber as shown in figure 1 to lift top plate. If chamber/ top plate to be lifted locking pins moved to top of chamber.



(a) (b)

Figure 2 a) Chamber with top electrode lifted and b) chamber and top electrode lifted to expose bottom electrode

Access to underside of chamber area is via interlocked stainless steel doors shown Figure 2.

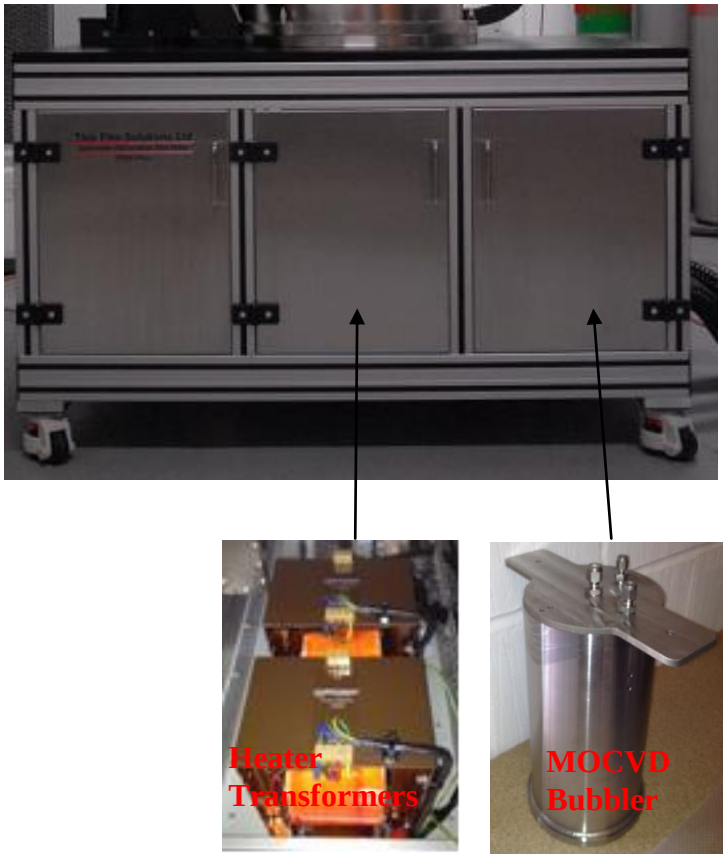


Figure 2 Front of system showing three off interlocked doors for access to area under the chamber. Four additional interlocked doors [not shown] – two doors each on right and left side of the system

Seven doors in total, three at front of system as shown in Figure 2 and two doors on both right and left side of the system.

1.1.3 Pumping System

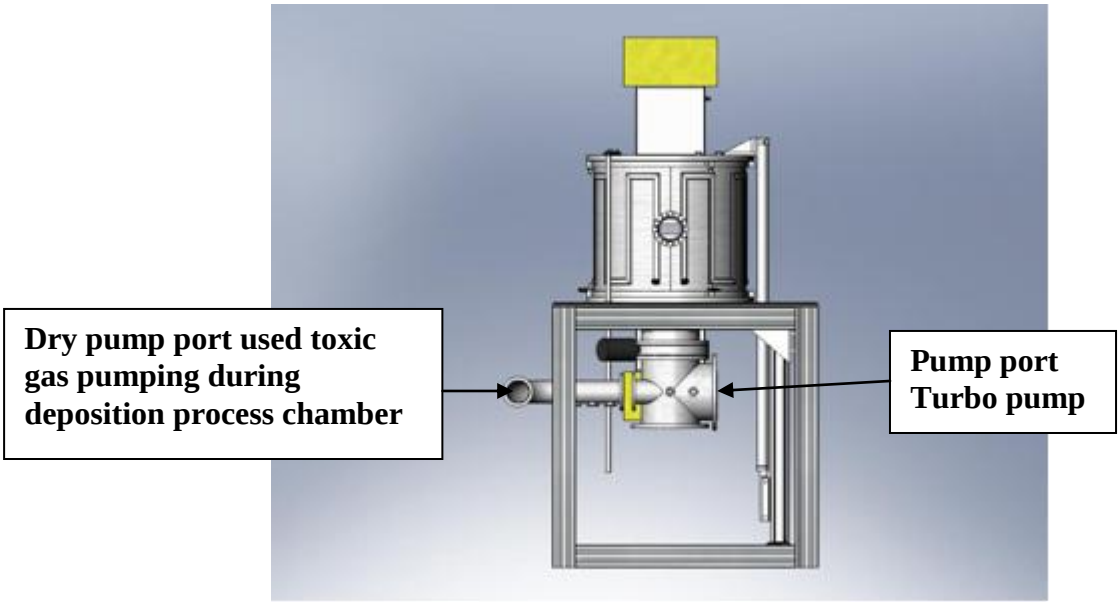


Figure 3 Pump port configuration

The system is configured to accommodate two pumps: turbo and a dry pump. Figure 4 shows turbo pump and backing line.

Figure 4 Edwards 1500l/s turbo pump and backing line

Figure 5 shows the Edwards dry pump and connecting line.

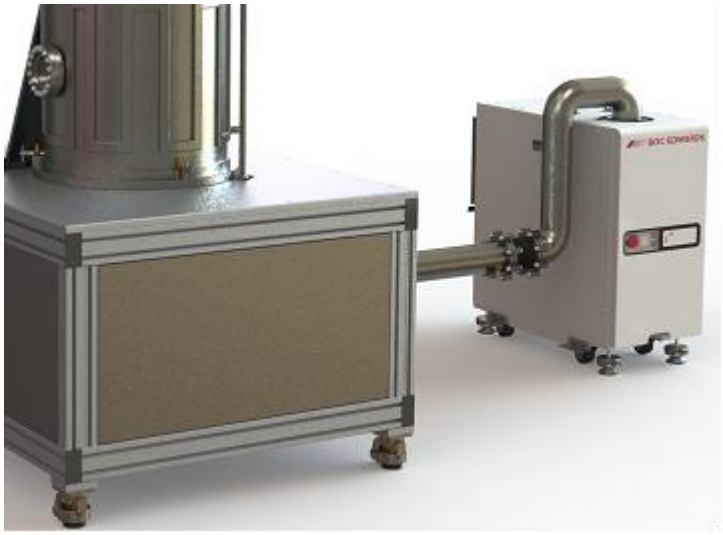


Figure 5 Edwards iH600 dry pump and vacuum line

1.1.4 Pressure control

- Down stream pressure controller using automatic ISO 200 variable throttle valve [shown in figure 6] ISO250].
- High corrosive resistance capacitance manometer for pressure feedback shown in Figure 6]

Figure 6 Automatically controlled variable throttle valve

Process pressure controlled between 1- 100 mtorr process. Vacuum gauging is mounted on the top plate as shown in Figure 7.

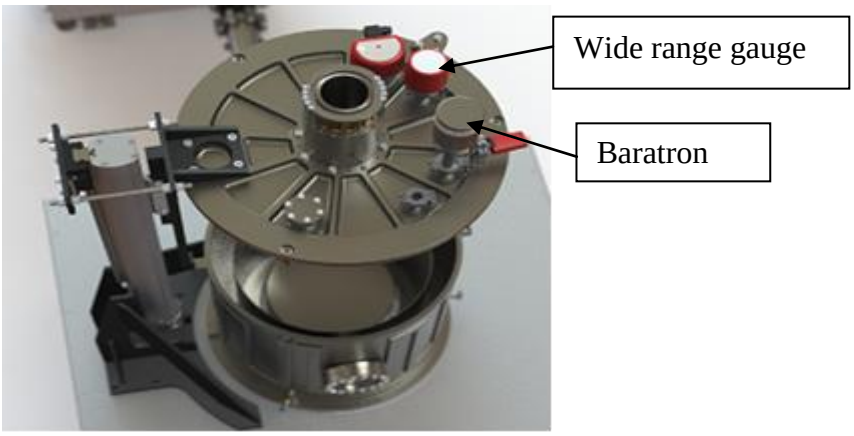


Figure 7 Vacuum gauging on top plate

1.1.5. Gas Control & Water Cooling

Seven channel mass flow read-out including a line to allow feed of a metal organic precursor is shown in Figure 8a. Access to the gas panel is via an interlocked door on the right side of the system – same door type as shown in Figure 2.

(8a)

(8b)

Figure 8a Gas panel showing 7 off mass flow controllers (argon [two lines – one for direct gas feed to chamber and a second for feed to the MOCVD bubbler], butane, ammonia, oxygen, silane and nitrogen; d) water flow circuit [turbo pump, dry pump, top and bottom electrode, chamber trace cooling and a spare line]

Figure 8b shows the water cooling circuit, located via an interlocked door on the left side of the system - same door type as shown in Figure 2b. Metered water cooling is in place for both the turbo and dry pumps, top and bottom electrode, chamber trace cooling and a spare line.

1.1.6. Electrode Set

Figure 9 illustrates a schematic of the bottom electrode configuration [top electrode configuration the same].

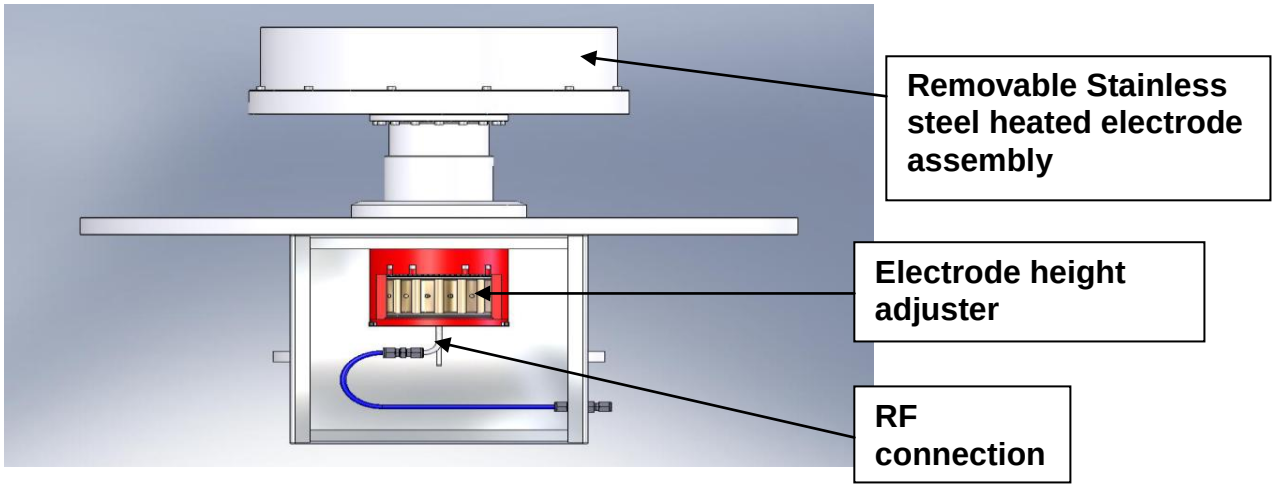


Figure 9 Schematic bottom electrode. Note top electrode identical

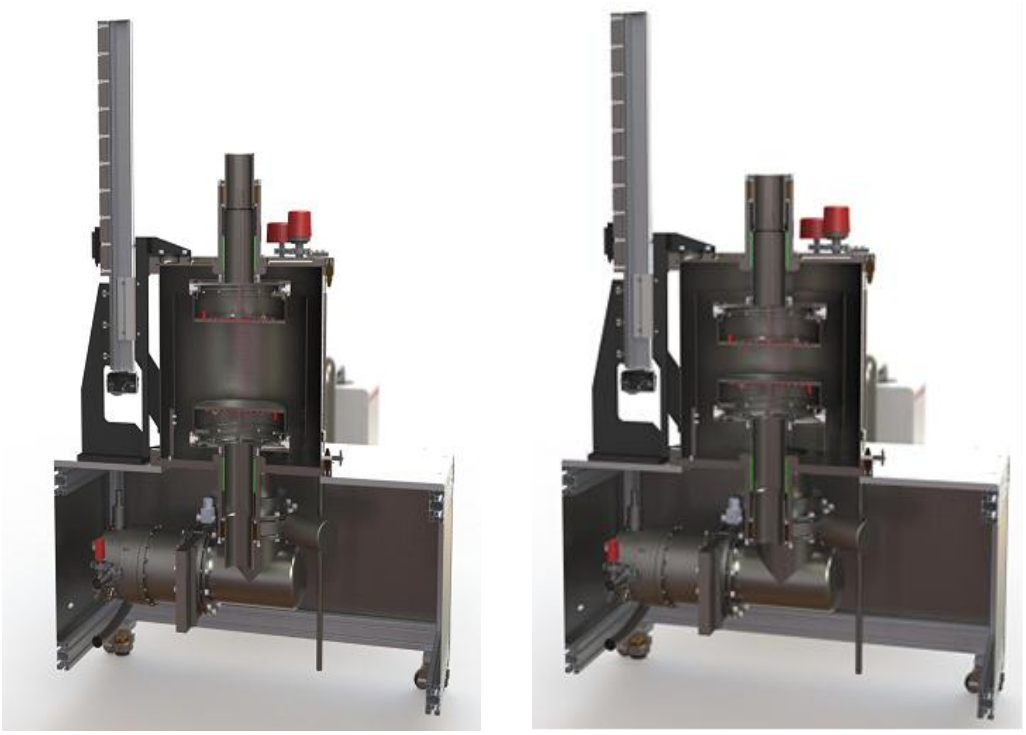
Top and bottom electrode are shown in figures 10a and b respectively.

(a) **(b)**

Figure 10 a) Bottom and b) top electrodes – planar type shown

Figure 11 shows heatshield mounted on bottom plate. Note two heat shields supplied.

Figure 11 Heatshield mounted on bottom plate



(a) (b)

Figure 12 Cross sectional view showing a) maximum electrode separation [250mm] and b) minimum separation [100mm]

1.1.7. Electrode Heaters

Electrode heaters installed top and bottom with inbuilt temperature sensing and control. Heaters sufficient to elevate electrode temperature to 500ºC, accurate to ±5%.

Electrodes (top and bottom) 300mm diameter – quality area 250mm diameter. Larger electrode diameter options are available

- 2kW RF power supply, switchable between top and bottom electrodes
- Stainless steel constructed with etching capability.
- RF power can be switched between bottom and top electrode as required
- Water cooled seals
- Automatic matching network [top and bottom]. Power handling capability 2kW
- Electrode separation 100mm to 250mm [see Figure 12 a & b]

Compressed air feed to both electrodes included to enable fast cooling and control of the electrode temperature.

1.1.8. Plasma Enhanced Metal Organic Chemical Vapour Deposition & Bubbler

In addition to PECVD the P500+ is also set up for MOCVD deposition. Instead of bringing in process gases from external cylinders, an organic precursor is loaded into a heated vaporizer (the bubbler) which is then preheated to an elevated temperature. Bubbler types may be immersive or laminar depending on the organic precursor and carrier gas. This model is the latter and the gas inlet feed pipe should not be below the liquid level in the bubbler reservoir and the inlet gas flows over the surface of the liquid feedstock.

To prevent contamination the MOCVD line should not be used for running argon processes in isolation. MFC#1 should be used instead. The bubbler should be left fully assembled when not in use.

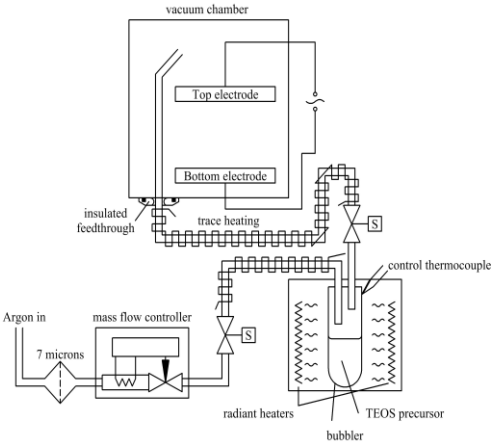
The bubbler consists of a reservoir held in a temperature controlled cavity.
Argon gas can be flowed through the bubbler, and either allowed to pass into the chamber through the bubbler isolation valve and an insulated feed through or may be pumped from the dry pump through the bubbler bypass valve. Note the lines prior to the bubbler, and between the bubbler and the chamber, are trace heated.

The capacity of the bubbler reservoir is about 35cc but a normal charge is 20cc. The bubbler supplied with the equipment should temperature stabilize within 15 minutes.
The maximum temperature that the bubbler can be used at is determined by the o ring used to seal the bubbler reservoir. For a viton O ring this is 150ºC. The trace heated lines should be held at typically 20 to 35ºC above the reservoir.

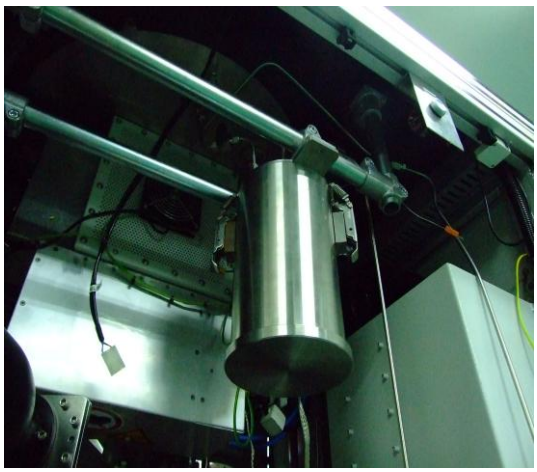
A typical SiO2 TEOS process might have

Bubbler temperature	35ºC
Trace heater	70ºC
Argon flow	10 sccm
Electrode temperatures	150ºC
RF forward power	150w
Pressure	10mTorr

Figure 13a and b shows a schematic of the MOCVD system integration into the system and the MOCVD bubbler located in the area below the chamber.



(13a)



(13b)

Figure 13a Schematic of MOCVD precursor delivery and Figure 13b MOCVD bubbler assembly (accessed via front left hand stainless steel door].

MOCVD operation is integrated with the control software driving the equipment, with valves and temperature control being asserted automatically. In addition, the MOCVD bubbler is located behind an interlocked panel, inhibiting operation of RF power supplies during load / unload, and the software opens the bubbler isolation valve during venting and initial pump down, to prevent excessive pressure build up.

1.2 Normal Operating Conditions

1.2.1 Expected Conditions of Electrical Supply And Other Services

Electrical Requirements

Type:	3 phase, Neutral and Earth
Rating:	$400V_{ac}$ +10% -6%, 50/60Hz, 63 Amps.

Fuse or circuit breaker protected to 63 amps per phase. Supply to be via isolator. Phase rotation critical.

Water Requirements

Temperature:	18 to 25 °C
Flow rate:	~30 litres per minute
Inlet pressure:	3 bar max.
pH:	7.0 to 8.0
Conductivity:	<200µS/cm
Hardness:	<7 milli-equivalent /dm^3
Maximum chloride content:	150mg/kg

Water mechanically clean, optically clear, without turbidity or deposits. No aggressive carbon dioxide or ammonia should be detectable. If the actual values are outside the levels indicated above and as a result problems arise with, or damages occur to the equipment supplied, this will void warranty and all liabilities. We recommend the use of a water treatment company to advise.

Compressed Air

Used for valve operation. In the range 5.5 to 6.0 bar. Air should be free of water and oils.

Process Gases

Argon, Butane and Oxygen are preprogrammed, as well as an Argon for the bubbler.
Six MFCs are fitted as supplied for PECVD plus one additional MFC for MOCVD
All gases to be regulated adjustable between +1 and 2 bar.
As delivered the gas lines will be labeled:

MFC	Gas Name
1	Argon
2	Ammonia
3	Buffered Silane
4	Nitrogen
5	Butane
6	Oxygen
7	Bubbler Argon

1.2.2 Physical Environment

The equipment has been designed to be operated in a normal factory environment, i.e. avoiding extremes of temperature, humidity, vibration and contamination.

1.2.3 Inappropriate Use(s) Of The Equipment

The equipment has been designed for the production of mechanical films by Plasma Enhanced Chemical Vapour Deposition (PECVD). Any changes to equipment usage must be advised to Thin Film Solutions Ltd before implementation otherwise warranty is voided.

1.3 Load Currents

Under normal conditions the load current will be less than 63 amps per phase.

1.4 Peak Starting Currents

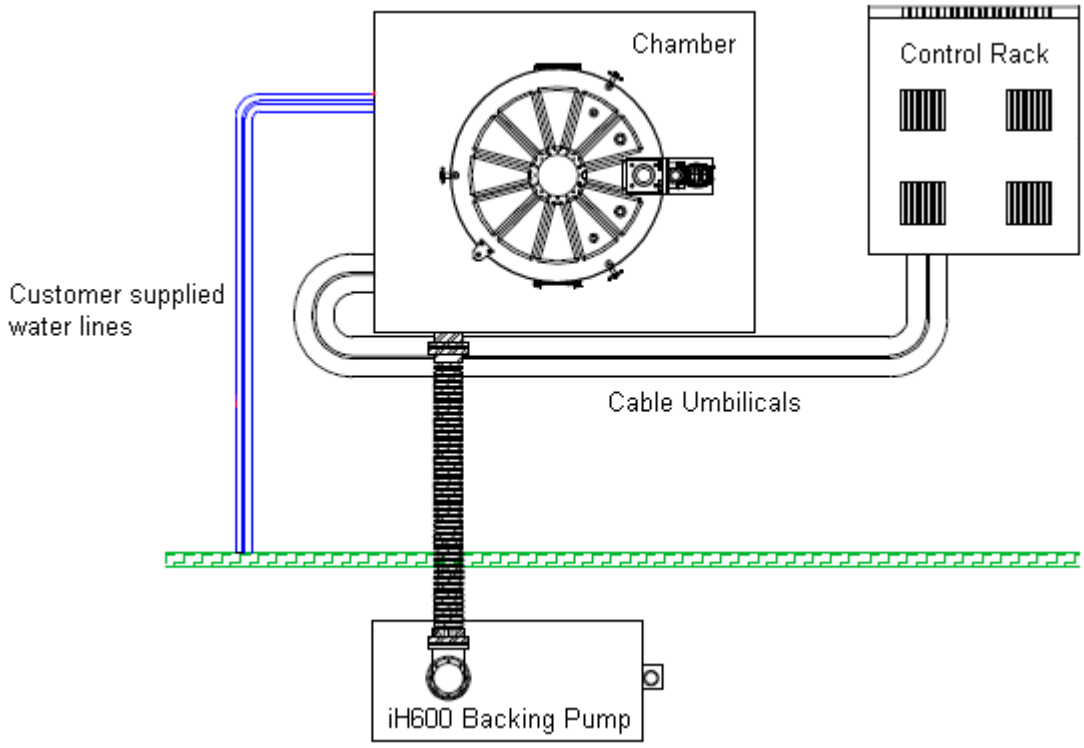
Under normal conditions the peak starting current will be less than 63 amps per phase.

1.5 Permitted Voltage Drops

Voltage range +10% -6%

2.0 Installation

2.1 Layout



Warning

Layout – Do not stretch the umbilicals and install a ground plane/earthing strip to ensure necessary earth connection.

2.2 Facilities Setup

Electrical mains connection must be made to the mains isolator on the rear of the control cabinet. Cable suitable for the maximum load should be used and protected accordingly. A good earth is required for reliable operation.

Phase rotation is critical. Check rotation direction of rotary pump, booster pump.

Water cooling input/outputs are to the right of the system and require a 12mm ID hose.

All gas connections are ¼ inch VCR fittings at the rear of machine.

Exhaust from the rotary pump should be piped to a suitable extraction system including a suitable scrubber when using dangerous and hazardous gasses.

For systems running toxic gasses a suitable scrubber based extraction systems must be connected to the chamber air flow valve and the MFC gas cabinet. Suitable leak detection equipment must also be used prior to enabling toxic gases to chamber.

2.3 Space Required for Removal or Servicing of the Electrical Equipment

A one metre gap around machine and control rack is recommended to allow for removal of panels and access for maintenance

3.0 Operating Manual

3.1 Operating Instructions for Computer Control

3.1.1 Start-up from OFF State

1. Ensure all services are supplied to the system as per the following check list.

Services Check List

Cool Clean DI water. Conductivity < 200µS/cm ☐

External CDA supply is on and available at 80 PSI. ☐

External N_2 supply is on and available at 40 PSI. ☐

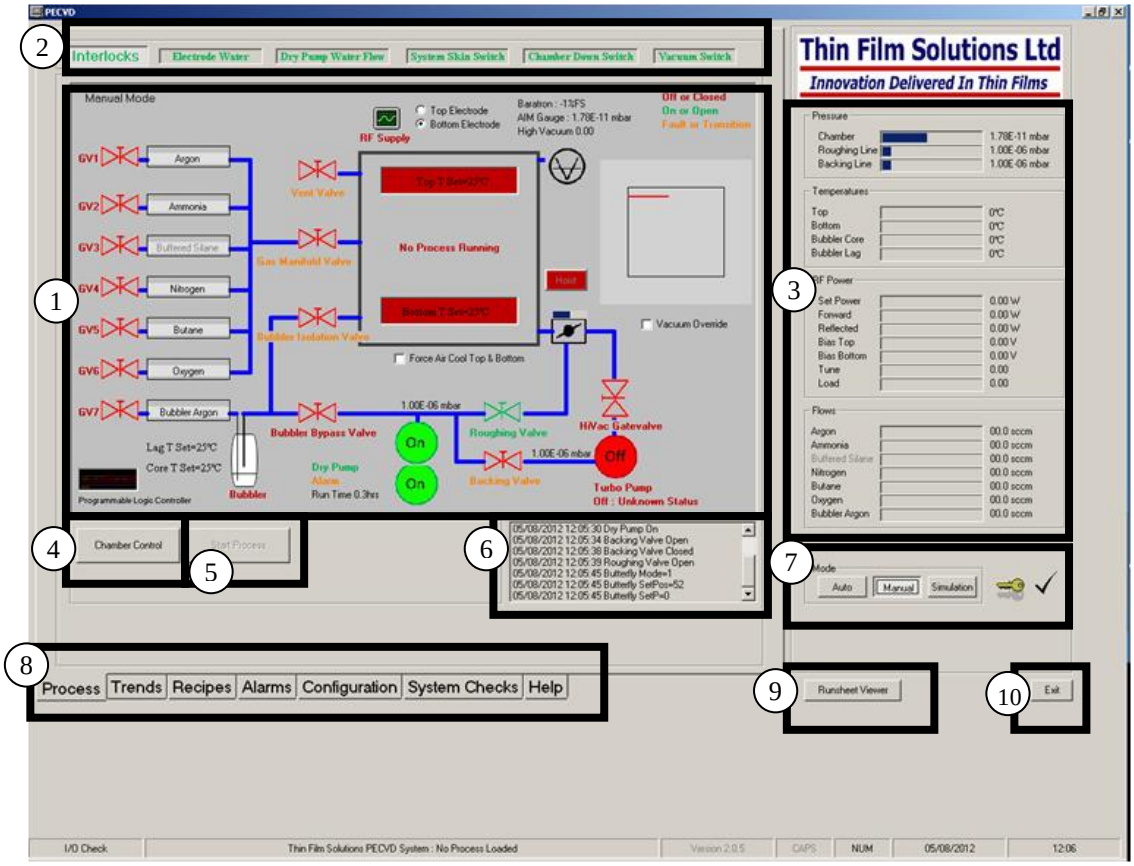
Extraction/scrubber system on and available. ☐

All process gasses fitted, leak checked and turned on. ☐

2. Switch on main isolator at rear of Electrical Rack.
3. Press the green start/reset button (Mains reset).

3.1.2 Computer System Power Up

1. Ensure that the system is on and the green “start” button on the electrical rack is illuminated.
2. Turn on the system PC and wait for windows to fully start up.
3. Double click the application icon and the software should start.
4. Before enabling power contactors user must be logged in by clicking on key icon.
5. Refer to the “Passwords” section for details on different access levels.
6. Once logged in (tick icon visible) click on “Chamber Control” on “Process” tab.
7. Ensure that it is safe to engage contactors and if so, click “Start Up”
8. System is now ready to control by software.



Main Screen and areas of note

1	Schematic of chamber state with colour coded description of pump / valve state
2	Interlocks Panel – shows which interlocks are made / not made
3	Quick View Panel – shows current values for pressures, temperatures, powers and flows
4	Chamber Control button –press for CC Panel for automated pump & contactor sequences
5	Start Process button – press to begin process selection & start
6	System State History Panel – logs each manual change of state request
7	Mode Selection Panel – press key to log in and allows selection of modes by button
8	Tab Selector – click to show other screens
9	Runsheet Viewer button – press to launch viewer software for previous runsheets
10	Exit Button – stops software control of hardware, deactivates contactors

3.1.3 Vacuum Control

3.1.3.1 Pumping Down

1. This function assumes the chamber is at air (atmospheric pressure).
2. Before starting ensure that the chamber is closed and ready to evacuate.
3. Click on the “Process” tab
4. Click on “Chamber Control”
5. Click on “Pump Down” when ready.

3.1.3.2 Venting

1. This function assumes the chamber is under vacuum.
2. Before starting ensure that the chamber is not too hot and no processes are running.
3. Click on the “Process” tab
4. Click on “Chamber Control”
5. Click on “Vent” when ready.

3.1.4 Recipe Control

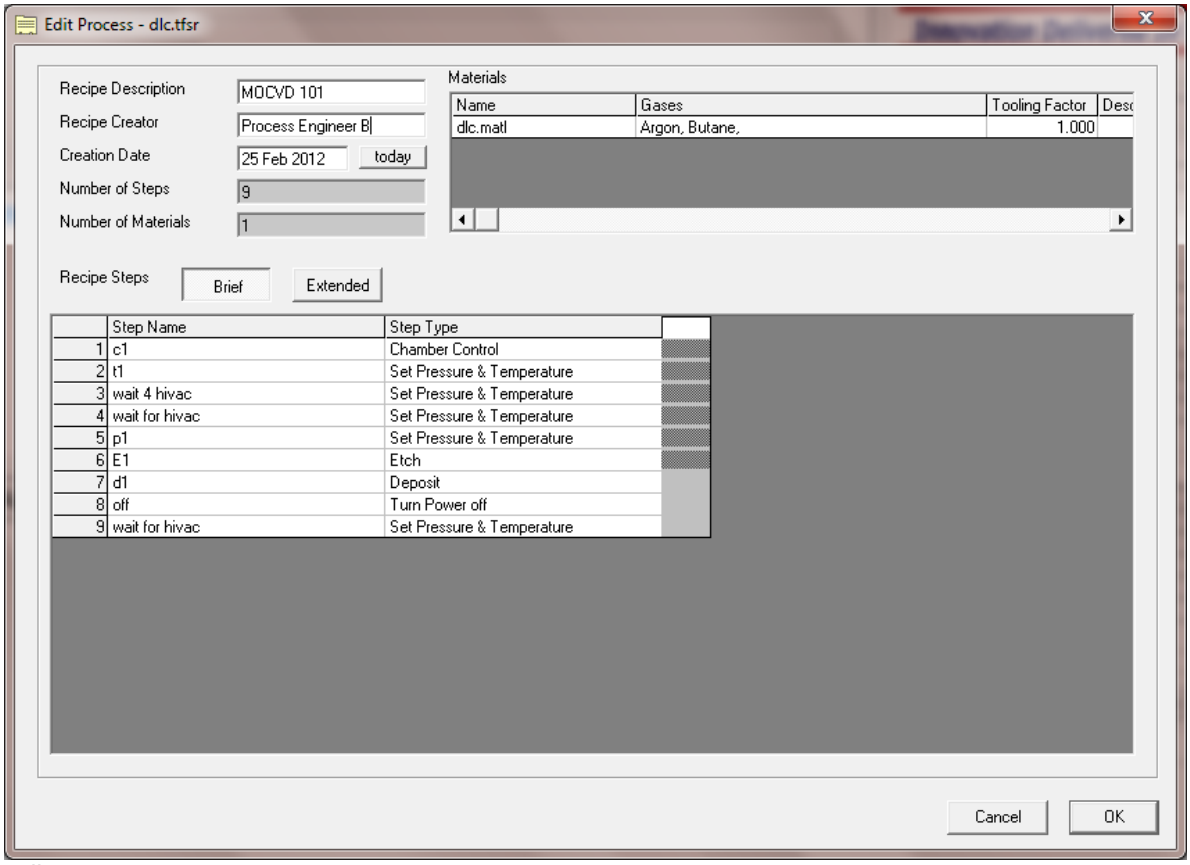
Recipes are files that contain process control information for consistent use of the same parameters.
These files comprise a series of “steps”; each one of these setting the chamber status and process variables, such as temperature, pressure, gas flows, plasma power etc. These steps are one of the following:

Step Type	Description of Control
Set Temperature and Pressure	Heaters, Inert Gas Flow, Butterfly Valve
Rate of Rise Test	Checks leak status of chamber
Etch	RF Power! Inert and Etch Gas Flows
Deposit	RF Power! All Gas Flows
Turn Power Off	Turns off RF
Chamber Control	Control of Pumps and Valves

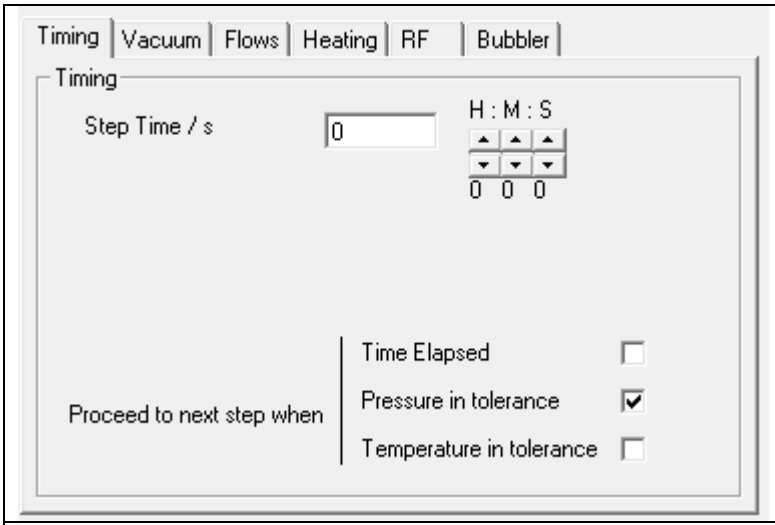
3.1.5 Editing a recipe

A recipe can be changed and overwritten. To enable this feature user must be logged in with Administrator privileges.
1. Click on “Recipes” tab
2. Click on recipe file to edit
3. Click on Edit

This now brings up the recipe viewing screen. Double clicking on a single step will load the step editor and allow changes to that step.

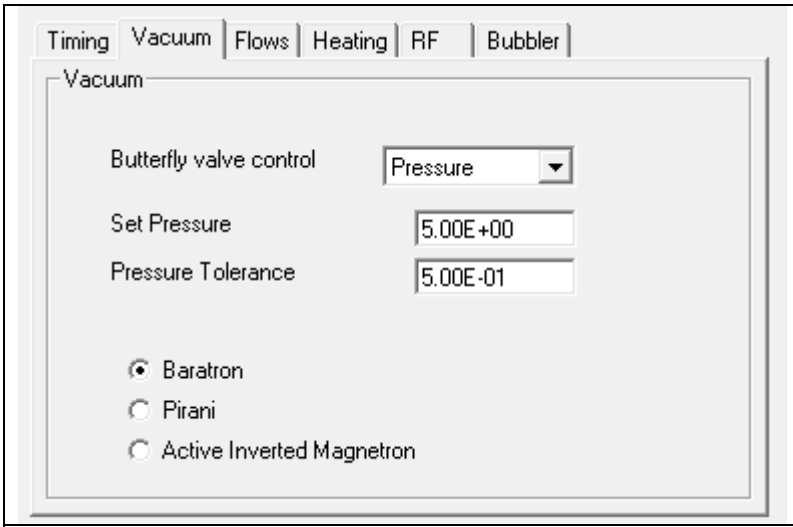


Edit Process Screen



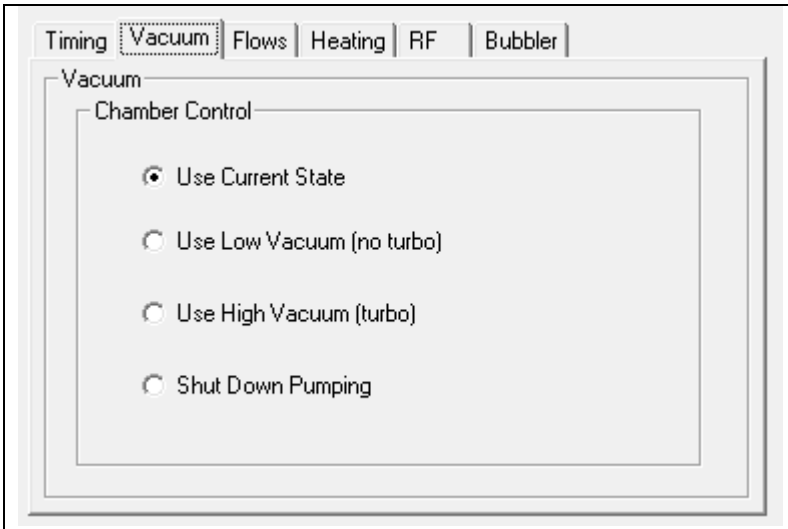
Set step time in seconds
Only complete step if time has elapsed
Only complete step if pressure is within range
Only complete step if temperature is in range

Timing tab



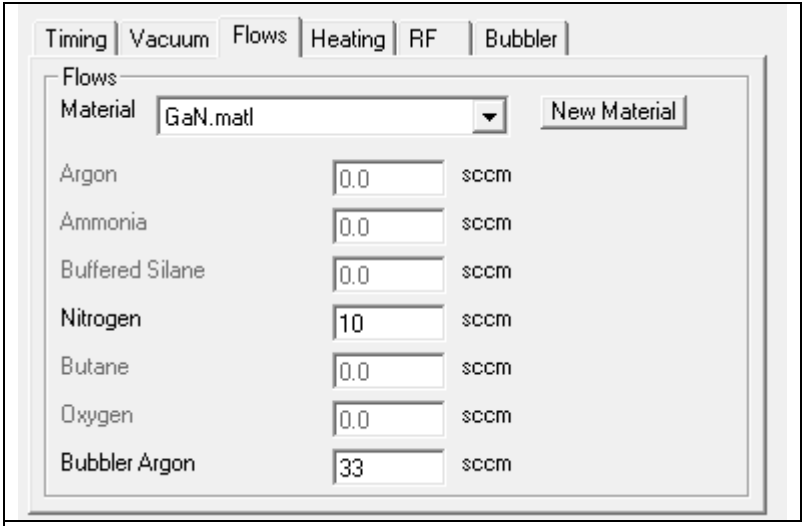
Butterfly Valve control mode : Position (0-100%) Pressure Fully Open (no options)
Target Pressure ± Permissible tolerance
Use Baratron gauge
Use Pirani gauge – for ultimate pressure setting not butterfly control.
Use AIM gauge – for ultimate pressure setting not butterfly control.

Vacuum tab – set temperature and pressure



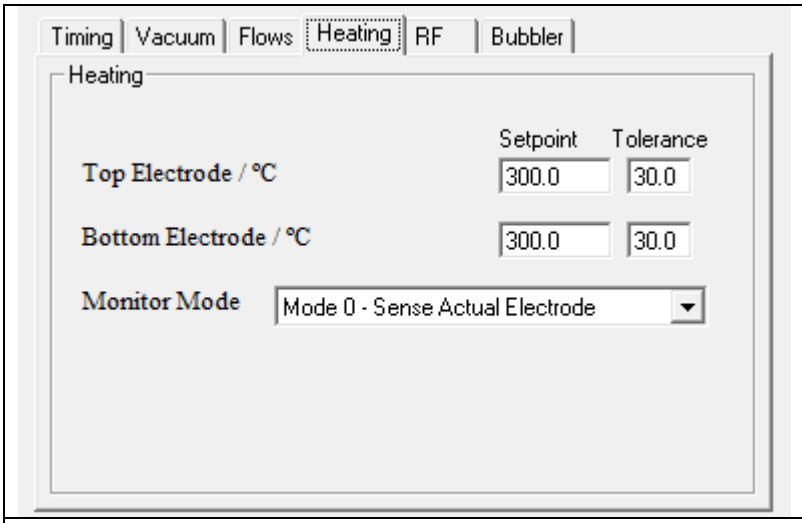
In chamber control step type then the chamber can be prepared for starting the process. This cannot work from air for safety reasons so system must be at least at rough vacuum.
Don't do anything to valves or pumps
Put system into dry pumped process state without turbo
Put system into high vacuum state with turbo
Shut down pumping (and close all valves)

Vacuum tab – chamber control



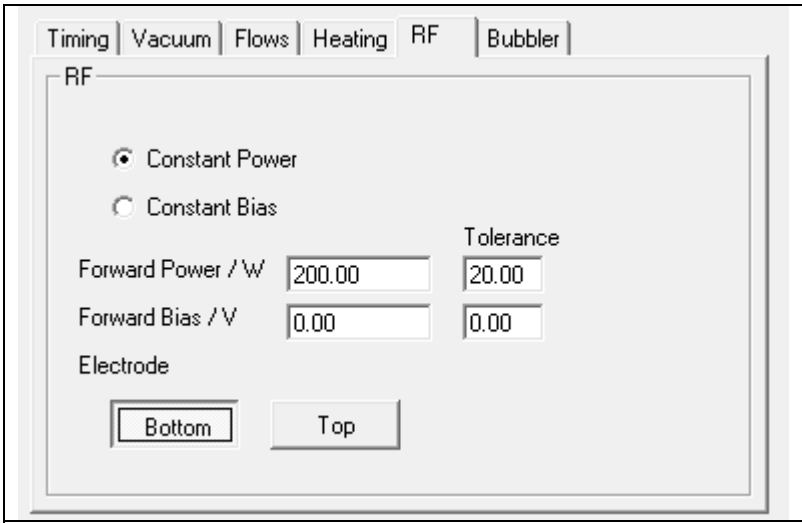
Material name being grown. New Materials can be created here and the related gases enabled.	
Flows on MFC attached to Gas Manifold. Must be enabled in material selected.	
Bubbler gas MFC flow set here	

Flows tab



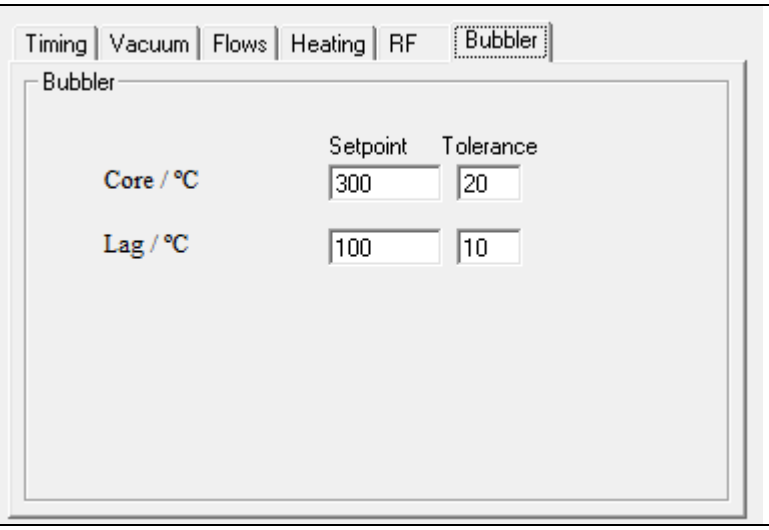
Adjust the temperature on the top and bottom electrodes	
Top Electrode set and tolerance Bottom Electrode set and tolerance	
Monitor Mode – allows cross sensing / control. If RF screen thermocouples installed then this is Mode 0 only.	

Heating tab



Set the RF mode, fixed power control or fixed voltage control.	
Set power (if power mode) or bias (if bias mode) and related tolerances.	
Select electrode. RF must be off if changing between electrodes.	

RF tab



	Set the main bubbler heater and tolerance
	Set the lagging or trace heater and tolerance

Bubbler tab

3.1.6 Deleting a recipe

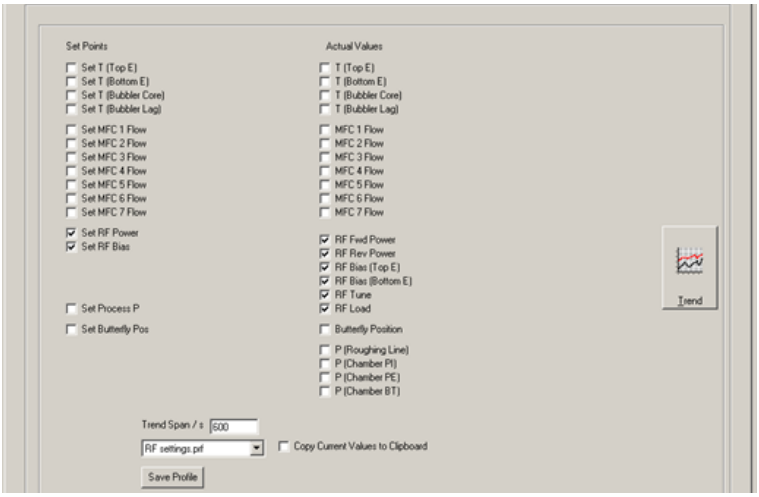
A recipe can be deleted when no longer needed. To enable this feature user must be logged in with Administrator privileges.

4. Click on “Recipes” tab
5. Click on recipe file to edit
6. Click on Delete

Click on OK to confirm delete of file when prompted.

3.1.7 Trending Screen

Whilst the instantaneous values are shown on the Quick View Panel at all times, sometimes it’s useful to view trends with time. This can be done by means of the Trends Tab and selecting the parameters to view. The user can simply click on the variables to trend and then click the Trend button on the right or select a previous trend profile from the drop down menu. To create a new trend profile: just select the variable to include and then click save profile along with a name for future reference.



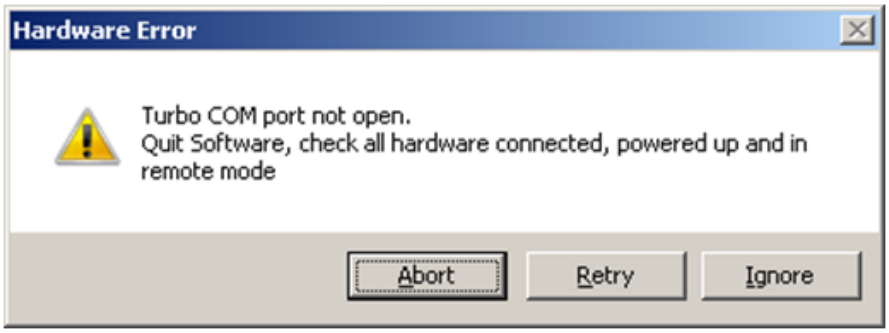
Trending Screen on Trends Tab

The default time span is 10 minutes (600s) but this may be changed as required from 5 to 5000 seconds, points outside this range will be dropped off the charts. Variables that can span several decades (such as pressure) will be displayed on a Log (base 10) chart whereas

other variables will be displayed on a linear chart. By clicking on the “Copy Current Values to Clipboard” checkbox it is possible to use the windows clipboard to monitor (or log) all variables to external software (such as Microsoft Excel).

3.1.8 Alarms Screen

Alarms are logged automatically to the Alarms Tab, clicking on this Tab enables the user to see any active alarms. If these are of a serious nature (such as a hardware communication fault) then the user will be made aware independently by means of a dialog; less serious alarms (such as an overdue maintenance action which may of may not be serious) will appear in the list but the user is not otherwise alerted.



Example of a hardware communication error dialog

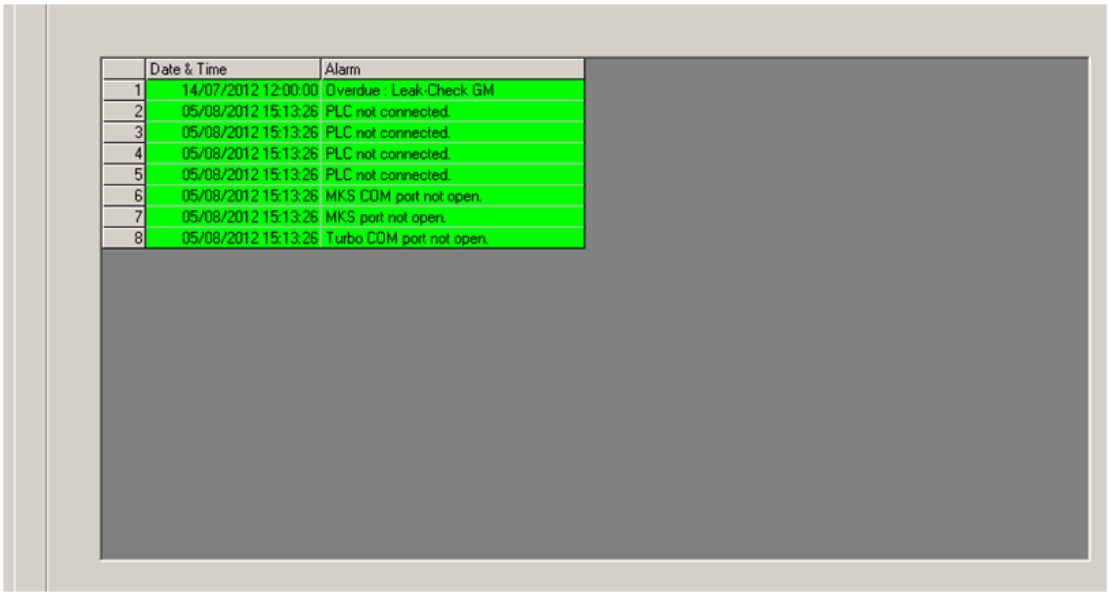
In the example above (a turbo pump controller communication issue), the user is given 3 options. The first “Abort”, will exit the software without attempting the shutdown any other hardware still running but is given as an option in the interests of safety. The second, “Retry” will attempt to repeat the last command in case the operating system or external hardware was not ready for the command issued. The last, “Ignore” will not re-alert the user to this error but will attempt to execute the command as normal.

Repeated “Hardware Error” notifications should be reported to TFSL along with a description of the situation and if possible a copy of the current logs to ensure that:

i) *No safety risk is possible*
ii) *No hardware damage is possible*
iii) *A software or hardware fix can be issued*

Notifications of the above type may occur in the P500+ for communication problems to the PLC, the turbo pump, the Eurotherm temperature controllers or the MKS pressure controller. It is important to identify which of these may not be functioning correctly when reporting to TFSL. It is recommended that the system is not used until any problems are discussed with TFSL.

Only current alarms will appear on the Alarms Screen, below shows a list of alarms as they appear by date & time. In this example there is an overdue maintenance item and the control computer is not actually connected to the system showing all of the possible communication alarms possible.



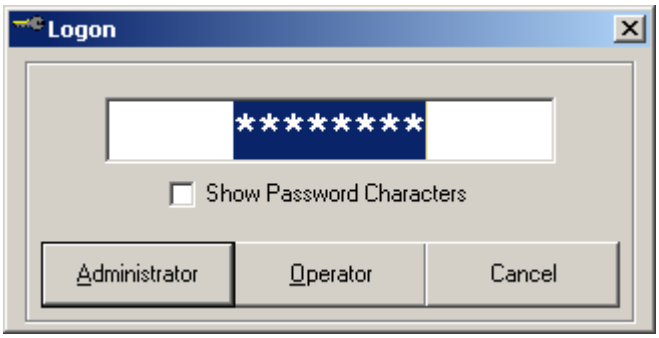
Alarms Screen on Alarms Tab

Alarms are reset by correcting the underlying problems.

3.1.9 Passwords

Password protection is set on the P500+ to protect users and equipment. The password levels are described as “Operator” and “Administrator” with the effective control detailed below:

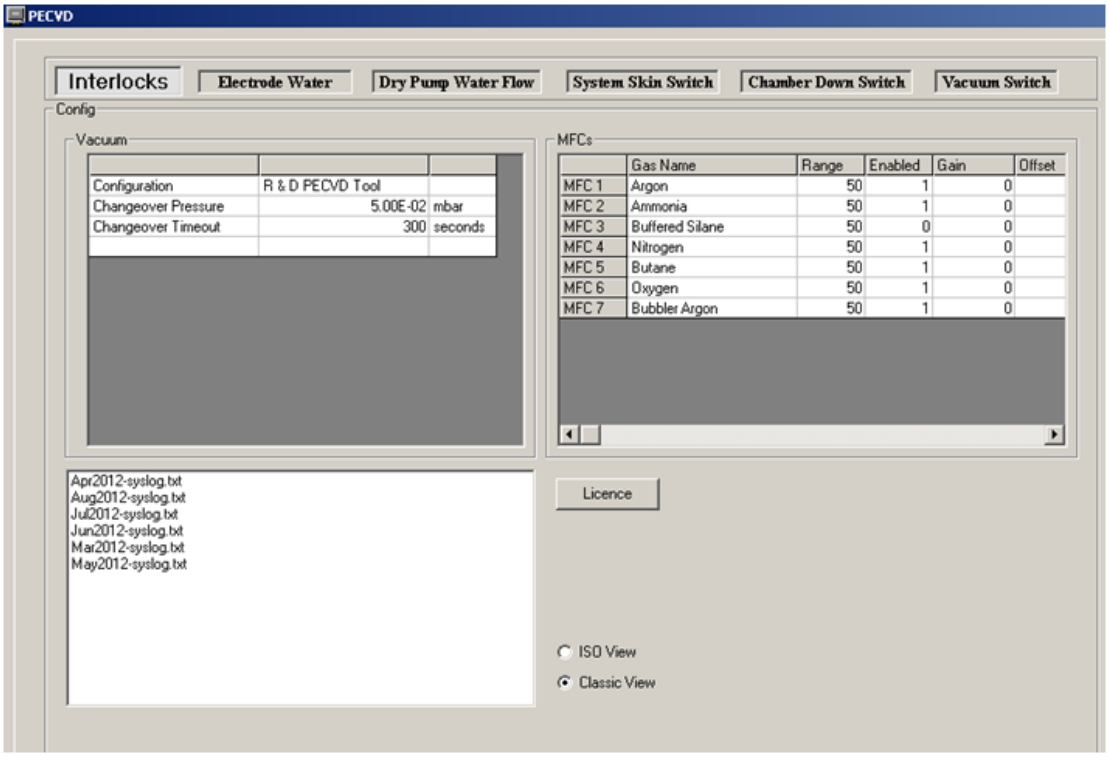
No Logon	Operator	Administrator
Can view logfiles Can view runsheets Can edit system checks Can read help files Can copy or rename recipes Cannot control processes Cannot control hardware manually Cannot edit, delete or view recipes Cannot load recipes Cannot change modes	All to left + Can start system Can load recipes Can run recipes Can use Auto Mode Cannot control hardware manually Cannot edit or delete recipes	No restrictions Can use all modes Can delete recipes Can edit recipes **Can over-ride some vacuum interlocks!**
	PECVD1	AMIN



Password Logon Screen

3.1.10 Configuration

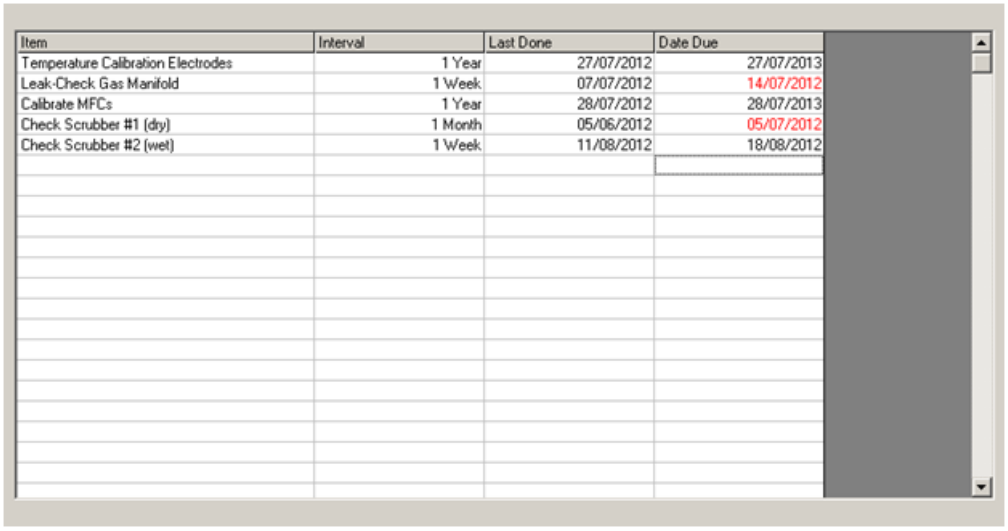
The Configuration Screen shows key information about MFCs (this can be changed on request to TFSL), pump changeover information, vacuum layout view (Classic or ISO symbols), systems logs sorted alphabetically and the Licensing button.



Configuration Screen on Configuration Tab

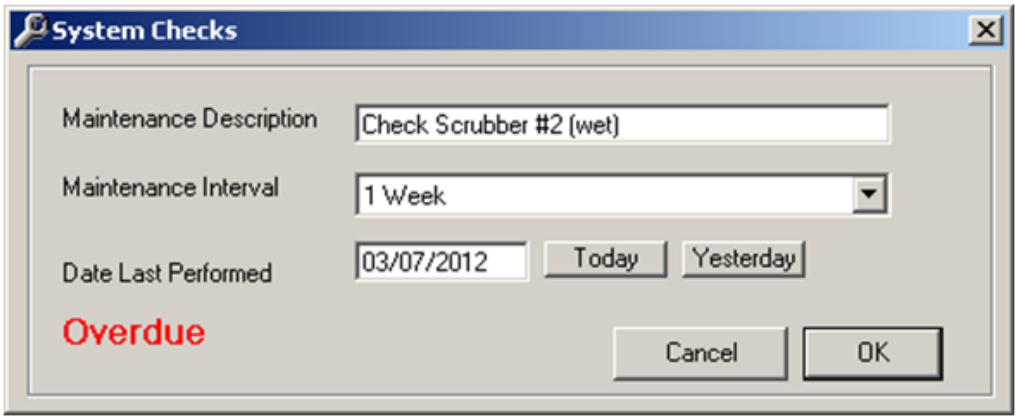
3.1.11 System Checks

The System Checks Screen is a utility to keep track of maintenance items that should be serviced or checked regularly. Operations passed the set maintenance interval will appear in red on the screen.



System Checks Screen on System Checks Tab

Double clicking on item will bring up the properties for it, if the row clicked on is blank then this will allow the creation of a new item.



An example check for an item (here a wet scrubber accessory, not part of P500+)

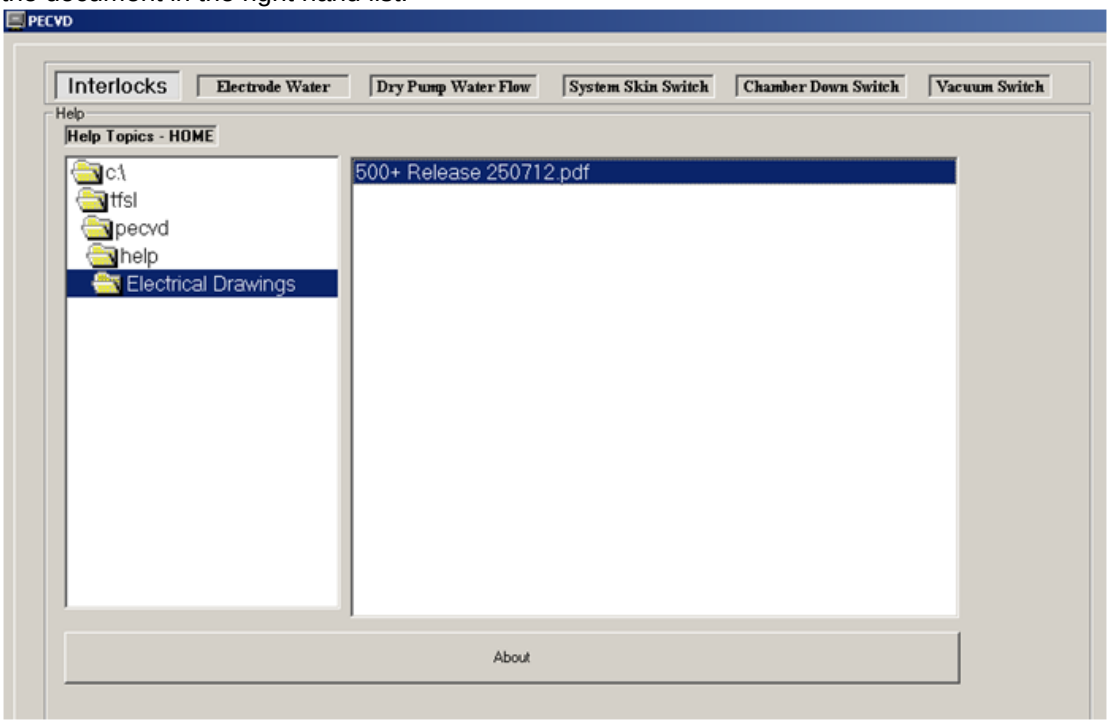
A due or past due item can be reset by entering the most recent date of maintenance (or clicking on two hot-buttons if appropriate).

3.1.12 Help

The Help section of the P500+ control software is a hierarchical file structure split into:

i) Software Use (this manual)
ii) Hardware Manuals (as many as can be provided in electronic format)
iii) Electrical Drawings

All of these help file are in PDF format and can be accessed by double clicking on the title of the document in the right hand list.



Help Screen on Help Tab

3.1.13 Manual Control

Manual control for any piece of attached hardware is possible if logged in as Administrator and clicking on the Manual Mode Button. Swapping between modes will close all valves and stop flows where appropriate.
For the majority of the vacuum schematic the manual control should be self explanatory. Software and hardware interlocks should protect the user and the system from erratic sequencing but the user is reminded no system is 100% foolproof and every effort should be made to ensure safe operation of this system.
For maintenance (such as cleaning inside valves etc) it may be desirable to override safety features by use of the Vacuum Override check function. Caution is strongly advised and only trained and experienced personnel should attempt to use this feature.

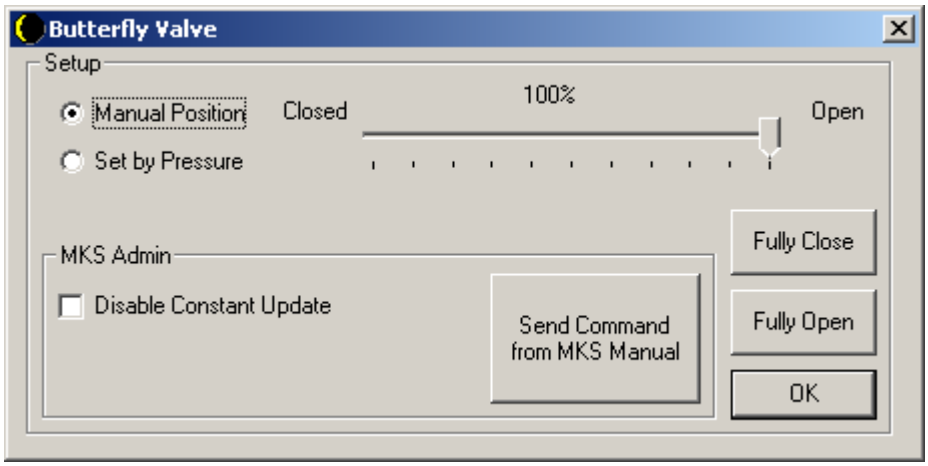
WARNING

A procedure or practice that could result in personal injury if not followed carefully.

CAUTION

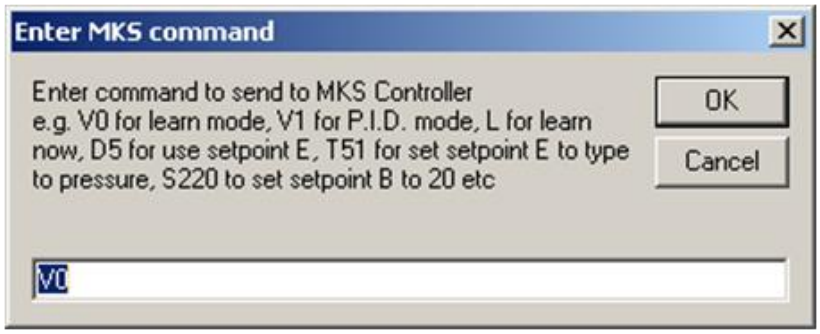
A procedure or practice that could result in damage to the equipment if not followed carefully.

Manual control is initiated by single clicks to the icons on the process screen to invert the state of pumps and valves. Note that the roots booster is controlled by the dry pump and cannot be separately controlled on this system.
The sequence that components are switched is important, for instance a dry pump should be switched on with the roughing, backing and bubbler bypass valves closed, the pump should then run for a minimum of 10 seconds before opening any vacuum engaging valve.
Similarly the turbo should not be switched on with a high gas load – much better that the highvac valve be closed prior to switching on and the turbo backed without any other load on the dry pump.
Gases should only be allowed to flow when they have a safe exit route, i.e. in the event of inert gases such as argon (and room temperature nitrogen) then via the dry pump to an exhaust line – in the event of toxic or pyrophoric gas use then safe capture or reaction scrubbers should be installed and appropriately tested with supporting safety metrology for leak escape detection and alarm.
Gases can be switched on when the chamber is pumped (low or high vacuum) and the gas manifold valve is open. At this point the MFC flow rates can be set and the corresponding gas isolation valves opened. The bubbler works in the same way, that is, the bubbler isolation valve must be open before the bubbler gas flow can be changed or gas isolation valve can be opened. A gas MFC will be **emboldened** when it is selected and either the slider or text box will accept a new gas flow which is activated when the “Gas Set” button is pressed. These MFC are all 50sccm maximum and the text box will reject values outside of the range 0-50.
Hover text for each valve and pump reminds the user what prerequisites should be in place prior to attempting to change the state of a component.
Control of the butterfly valve can be made by clicking on the symbol on the vacuum schematic which shows the screen:



The MKS butterfly valve controller screen

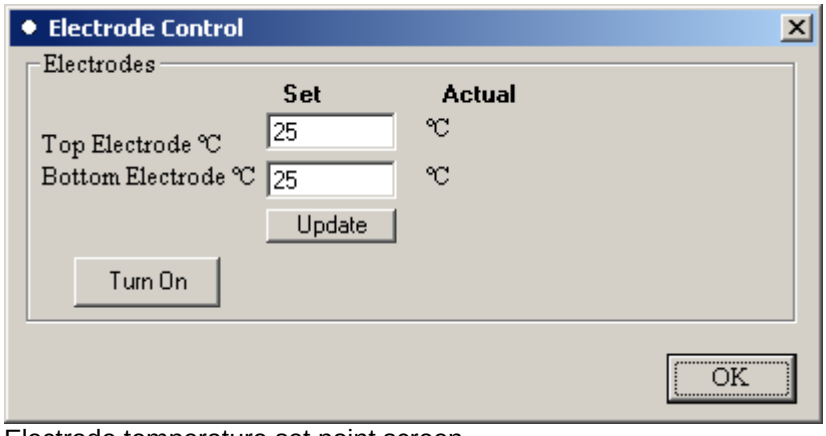
This allows for either control by physical position on the valve from 0-100% (fully closed to fully open) or by 100% of pressure (by range of sensor). In addition other commands can be issued as read in the MKS manual via the “Send Command from MKS Manual” button.



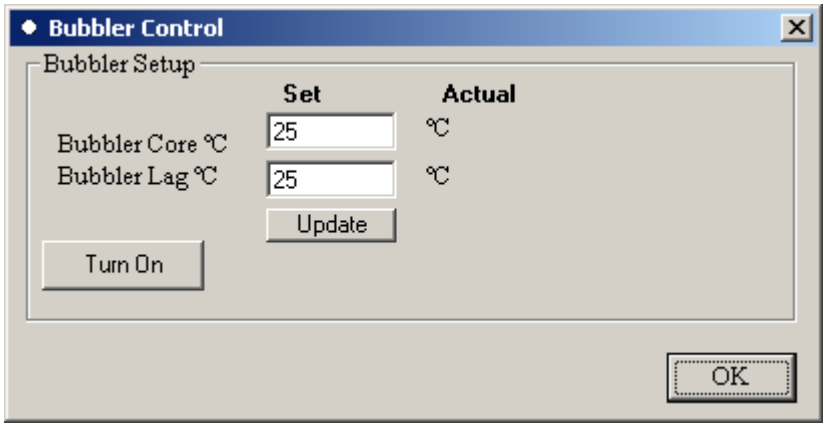
The MKS command sender

Here some command examples are given but the advanced user is referred to the OEM manual for more detail.

Temperatures also can be adjusted via the vacuum schematic interface:



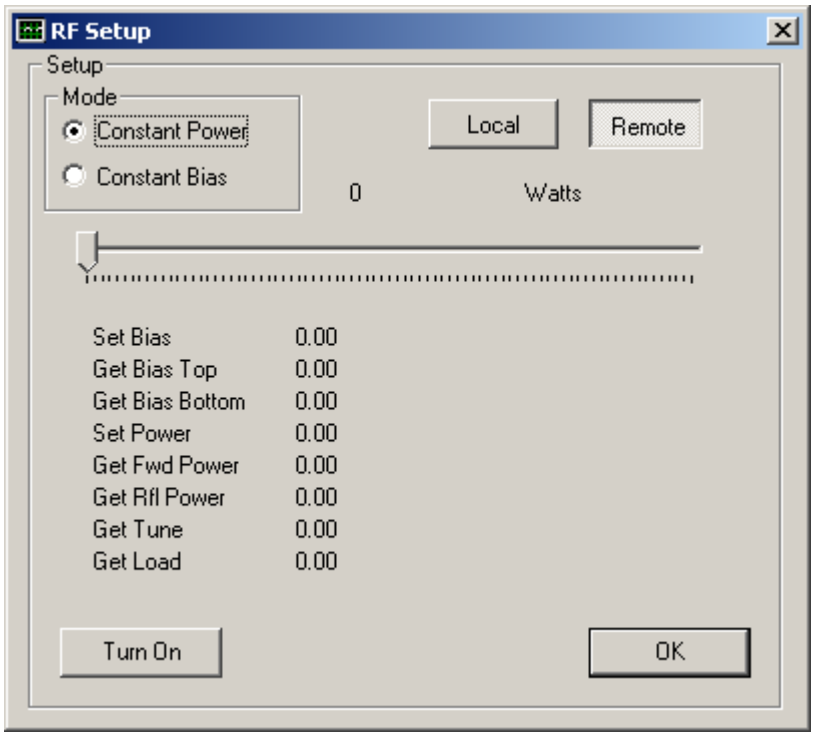
Electrode temperature set point screen



Bubbler temperature set point screen

It should be noted that the electrode heaters have RF screening transformers and an independent contactor that switches when the “Turn On” button is pressed however the bubbler does not have an addressable contactor, instead this is enabled on system power up and disabled on power down; to disengage the heaters on the bubbler core and lag the setpoint should simply be set to below the current temperature, by default this is 10ºC.
Also of interest is the cooling capability on the P500+ for the electrodes only, this is made possible by the air solenoid that engages by means of the eurotherm controllers and makes high precision temperature control possible (a few degrees with hundreds).

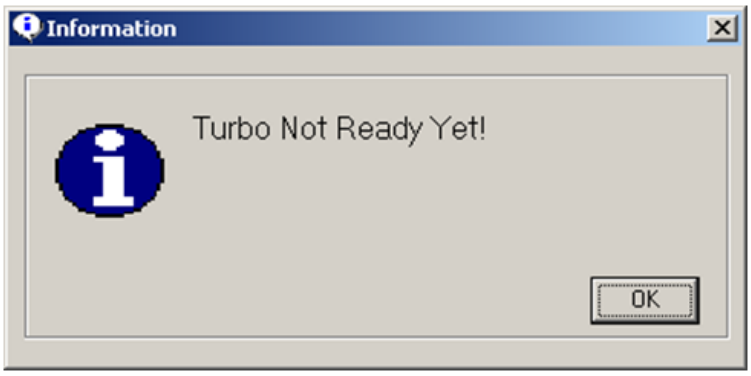
Finally on the manual control mode is the RF Setup screen by clicking on the RF generator symbol (sinewave). This allows the advanced user the ability to set operation mode for the RF supply, power or bias value and monitor the forward and reflected values along with the actual tune and load setpoints from the autotune unit (these cannot be manually changed but may be useful in ensuring repeatability of plasma conditions within the chamber). When the RF supply is turned on (“Turn On” button) the electrode selection on the main screen is disabled prohibiting unsafe switching of the electrodes whilst powered up.



RF Setup screen

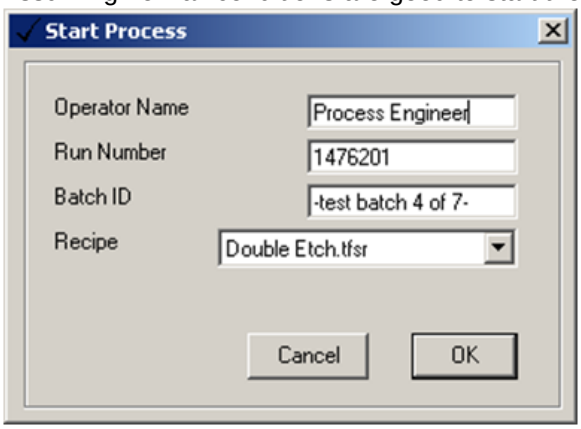
3.1.14 Running a Process

Running processes should be attended at all times in the interests in safety for the equipment and personnel.
Processes running in "Automatic Mode" may be pumped in high vacuum conditions (with Turbomolecular pump backed by dry pump and booster) or in low vacuum conditions (roughed with dry pump and booster only). In order to start any process however the chamber should start in high vacuum to prevent minimum atmospheric gas contamination of the process and promote maximum repeatability.
On the "Process Tab" the start button will be enabled when a user is logged in, the system is on and when all the interlocks are made.
It is also required that the Turbo has finished spooling, if it has not yet reached maximum acceleration then the message below will be displayed:



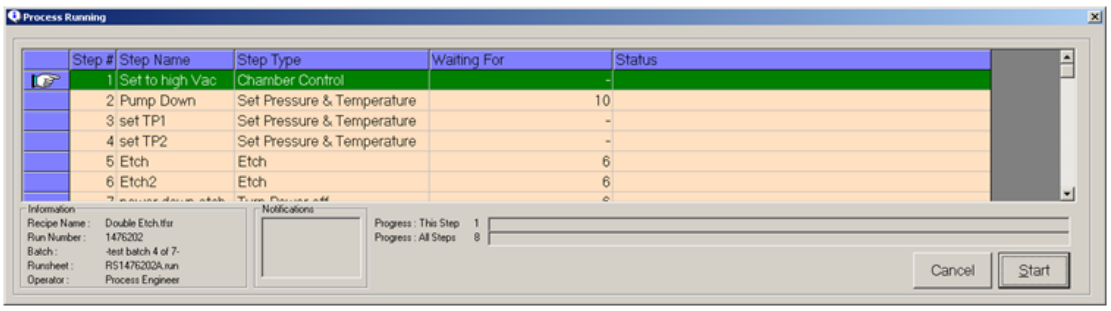
Awaiting the turbo acceleration to complete

Assuming now all conditions are good to start then a new screen is displayed:



Start Process pre-screen

Here details on the upcoming run can be entered including operator name, unique run number and also select the recipe to be run, if one has previously been loaded on the "Recipes Tab" then this will be the default but still the user has the option to pick any existing. Clicking OK will now progress to the "Process Running" screen:

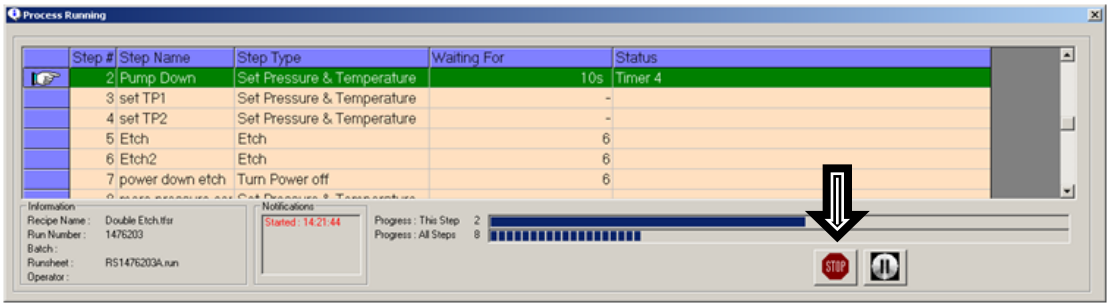


Process Running screen

Pressing “Start” will now initiate the first step of the pre-written recipe file. Each step will now be executed in turn, completion of each step is determined by the step type and selected options (i.e. if step type is “Set Pressure and Temperature” time elapsed, pressure, temperature or in the case of “Turn Off Power” then once the commands have been issued to the hardware affected).
Note that careful attention is required to ensure that a step can be completed!
Selecting the “Pressure in Tolerance” and then setting the pressure to a value that cannot be achieved will result in the recipe waiting indefinitely for that pressure. Similar results may be possible with unrealistic temperatures or tolerances.

3.1.15 Aborting a Process

If a process needs to be aborted for whatever reason (not achieving a step completion requirement, cylinder running low on a gas, bubbler depleted, water chiller fail etc) then the run can be aborted by clicking on the stop button:



The Abort Button

If the user believes a process has become unstable or the results are likely to be unusable then this button should also be used. This button may also a degree of safety for some type of hardware issues and the user should consider if the use of this button or the EMO (emergency off hardware switch) is more appropriate. The sequence for the Abort button is described by the software hover text, but in order is:

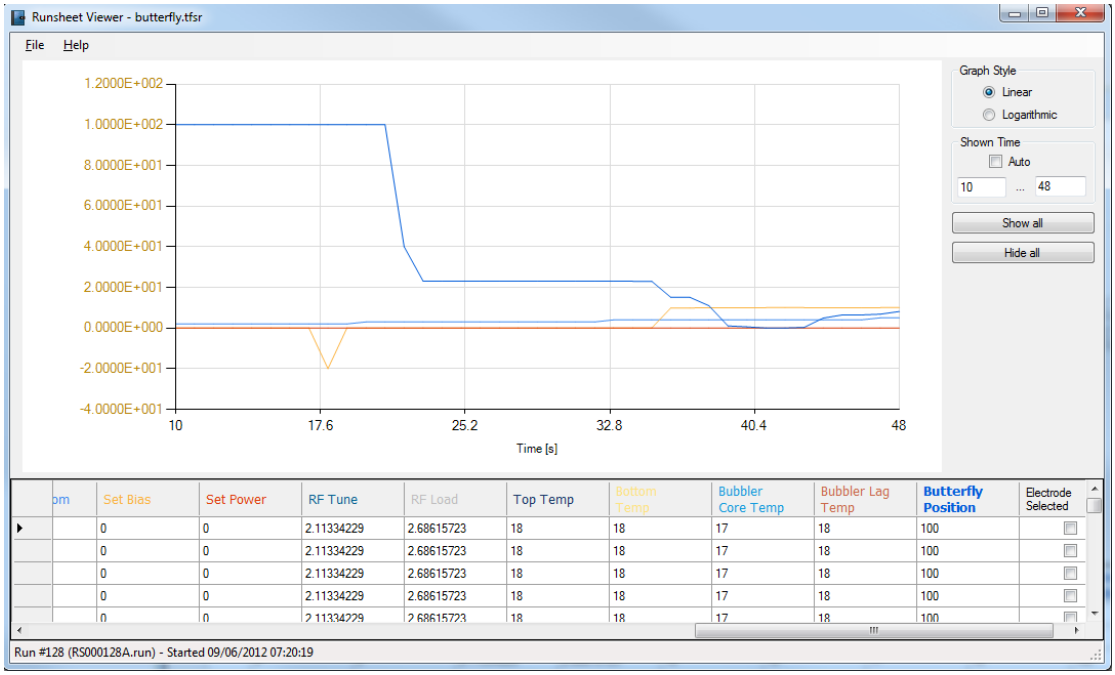
1) Close Gas Manifold Valve
2) Close Bubbler Isolation Valve
3) Turn off all gases (MFCs to zero and gas isolation valves closed)
4) Turn off RF

This process should be less than one second execution from start of button press to last command.
The Abort Button does not change the state of pumps, pumping valves or heaters.

The adjacent button to the Abort Button is a Pause Button and will not change the state of the system at all but temporarily stops counting time or checking completion conditions while the process continues running.

3.1.16 Retrieving a Runsheet

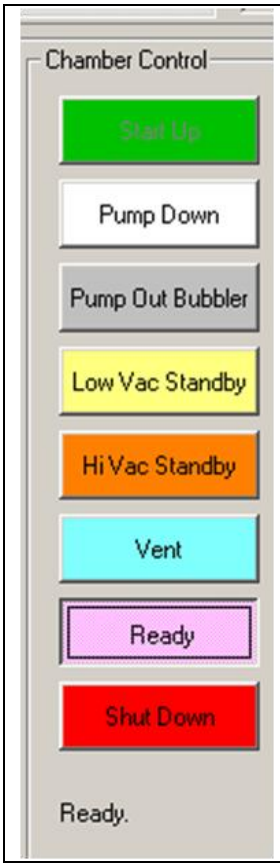
Clicking on the Runsheet Button (item 9 on Page 19) launches a new programme. This allows the user to open an existing runsheet and view any or all the variables as a function of time. Note that for long processes these files may be very large as variables are stored every second. It is advisable to open only one instance of this programme at a time due to the large memory management required by the operating system.



Runsheet Viewer

3.1.17 Chamber Control & Shutdown Description

On the "Process" tab, clicking on the "Chamber Control" Button shows and hides the Chamber Control menu. When no processes are running it is possible to shutdown the system including all of the attached sub-control systems. This is a safe standby state for the control rack and attached hardware.

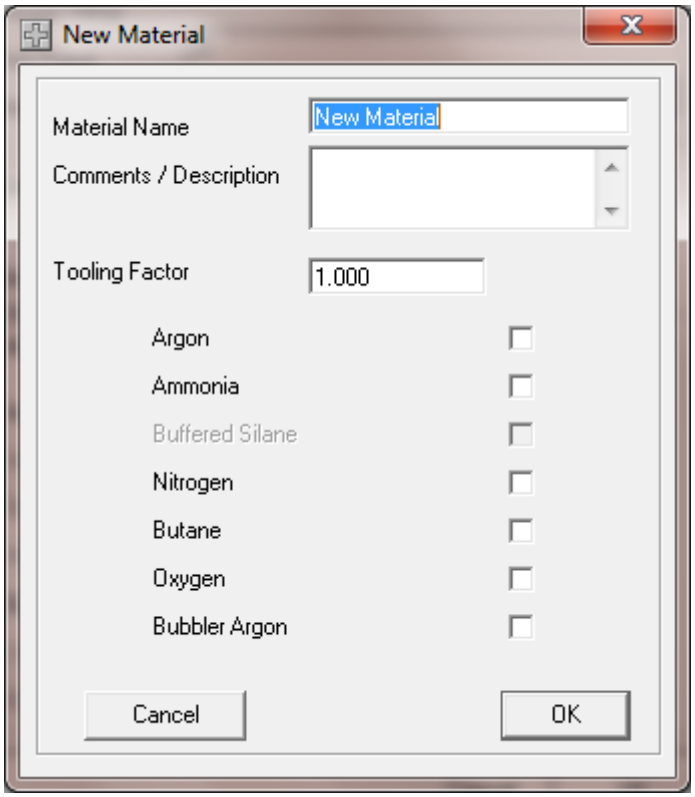
	**Start Up:** Enables all contactors attached to start up ring – Contactors(2,3,4,6,7 On) (RP, TP, RF PSU, RF enable, Heater 1, Heater 2) (See electrical drawings for more detail if required)
	Pump Down : Close VV, RV – wait 2s –RP On – wait 20s - Open ButV + RV – wait for changeover pressure – Close RV – wait 2s – Open BV, TP On – wait 10s – Open HVV
	Pump Out Bubbler : Close GV(6), RV,BV,BIV,BBV,HVV – TP Off – wait 5s – RP On – wait 10s - open BBV – wait 60s – close BBV
	Low Vac Standby : Close VV,GMV, GV(All),BIV,BBV,BV,RV,HVV – wait 5s – RP On, TP Off
	Hi Vac Standby : Close VV,GMV, GV(All),BIV,BBV,BV,RV,HVV – wait 5s – RP On – wait 10s – Open BV, TP On
	Vent: Close GMV, GV(All),BIV,BBV,BV,RV,HVV – wait 10s – Open VV – wait until atmosphere – Close VV
	Ready: No active chamber control sequences, ready for manual or auto control
	Shut Down: Close VV,GMV, GV(All),BIV,BBV,BV,RV,HVV RF set power & bias=0 – wait 5s – RP, TP Off – wait 5s – Contactors(2,3,4,6,7 off) (RP, TP, RF PSU, RF enable, Heater 1, Heater 2)

Chamber Control Menu after Start Up

Shorthand	Description
RP	Dry Pump
TP	Turbo Pump
RV	Roughing Valve
VV	Vent Valve
HVV	HiVac Valve
ButV	Butterfly Valve
BIV	Bubbler Isolation Valve
GMV	Gas Manifold Valve
GV(X)	Gas Valve (gas channel # : 0-6)
BV	Backing Valve
Key to pump and Valve Shorthand	

3.1.18 Creating a New Material

When creating a process recipe for a new material the advanced user needs to specifically create a material identity file and enable the required gases. Here also the tooling factor can be changed, by default this is 1.000 – changing this factor will multiply all set times by this value in any occurrences when found with this material name in any recipe files. Whilst this may be useful rather than calculate rates for each particular configuration it is recommended to leave this value as 1.000 and use the set time based on the calculated rate to account for any changes in RF settings and flow rates not set in this identity file.

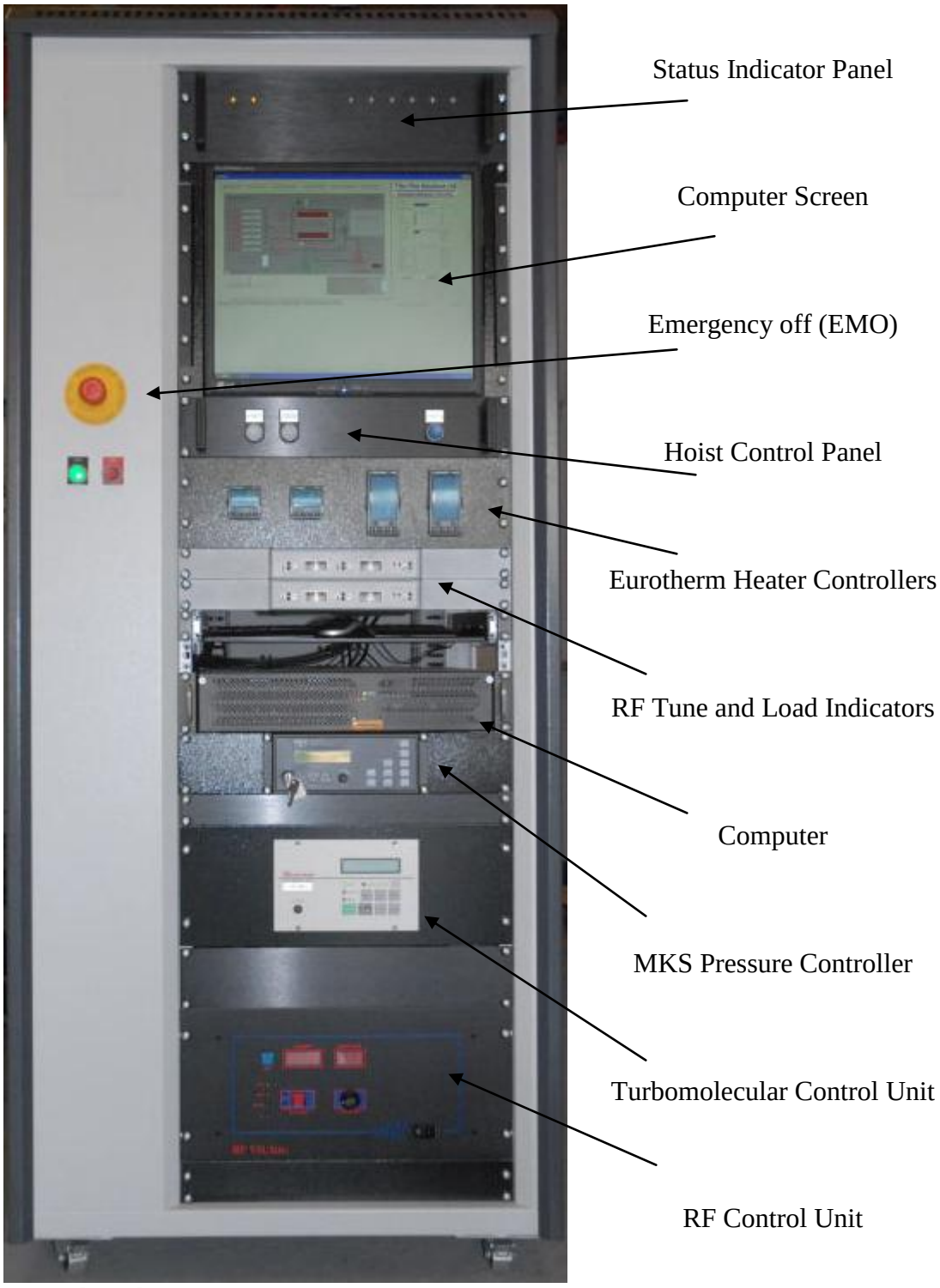


New Material Identity Screen

Notice that this screen will not allow MFCs to be used that have been disabled in the master configuration file.

After a new material is created it will automatically appear in the list of available materials for deposition in the Recipe Edit Screen, Flows Tab.

4.0 Control Rack



Control Rack Front Layout

4.1Status Indicator Panel

The status indicator panel displays confirmation of the +15 and -15V supplies on the left (two amber LEDs) which are required for the MFCs. The green status LEDs from left to right display the water flow state for Bottom Electrode, Top Electrode, Turbo Pump Bearing, Dry Pump, Chamber Walls and Spare (for any future requirements).

4.2 Computer Screen

Computer screen for display of system computer controller. This model is not touch controlled.

4.3 Emergency off (EMO)

Emergency off button for immediate shutdown of all pumps, valves and power supplies. Push to kill power, pull to enable reset.

4.4 Hoist Control Panel

Hoist controller is manual for maximum safety. To enable motor press and hold right hand button and select either up or down with left hand button. Hoist is only enabled when the software has determined that it is *reasonable* to move the chamber it does not know when it is *safe* to do so.

WARNING

Hoist is controlled by powerful motor. System should be operated by only one person for minimal risk.

4.5 Eurotherm Heater Controllers

The Eurotherm controllers are connected to the computer and under normal operation fully controlled by the software, they display set point temperatures and also actual temperatures on Bubbler Core, Bubbler Lag, Top and Bottom Electrodes (Left to Right).
For more information on the manual use of the respective Eurotherms refer to the manufacturers manuals.

WARNING

When controlled manually there is no limit to the maximum temperature fed to the electrodes.

4.6 RF Tune and Load Indicators

Tune and load feedback is displayed here by means of moving coil meters. These are for information only as the system is autotuning. The software can also display these values for the selected electrode.

4.7 Computer

The 19" rack mounted 2U high reliability industrial PC from Amplicon is preloaded with Microsoft Windows XP Professional for Embedded Systems (FES) 32-bit.
In addition to the operating system the following software is installed:

1) Adobe Acrobat Reader (for reading manuals)
2) Team Viewer (for remote control if requested)
3) TFSL PECVD Control software

No other software should be installed on the computer without first consulting the TFSL technical team as loss of processor power may result in reduced control reaction time.

WARNING

PECVD control software requires heavy processor usage, do not slow computer down with additional software.

4.8 MKS Pressure Controller

The MKS Pressure Controller under normal operation is fully controlled by the computer. On the front panel however there is a key switch to allow the advanced user to move from "Remote" to "Local". In local mode the advanced user can change auto-learn functions, calibrate for different gauge heads and apply movement limitations. Reference is made to the MKS manual for more information.

4.9 Turbomolecular Control Unit

The Edwards Turbo on the P500+ is an advanced levitation model with status feedback for each step. The status can be read from the front panel and also from the software. In normal operation the computer will control this module and no user intervention is required (or recommended).

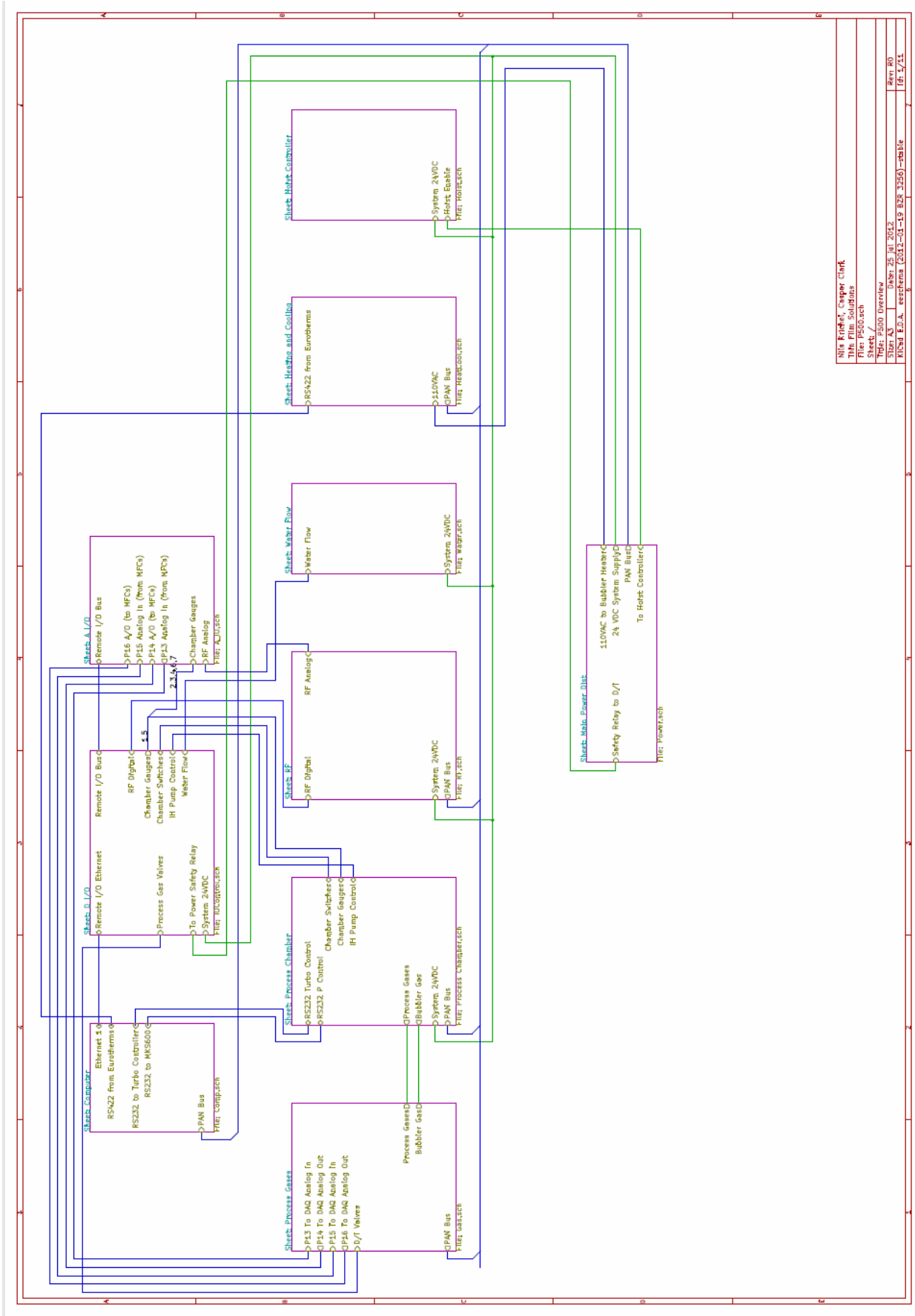
4.10 RF Control Unit

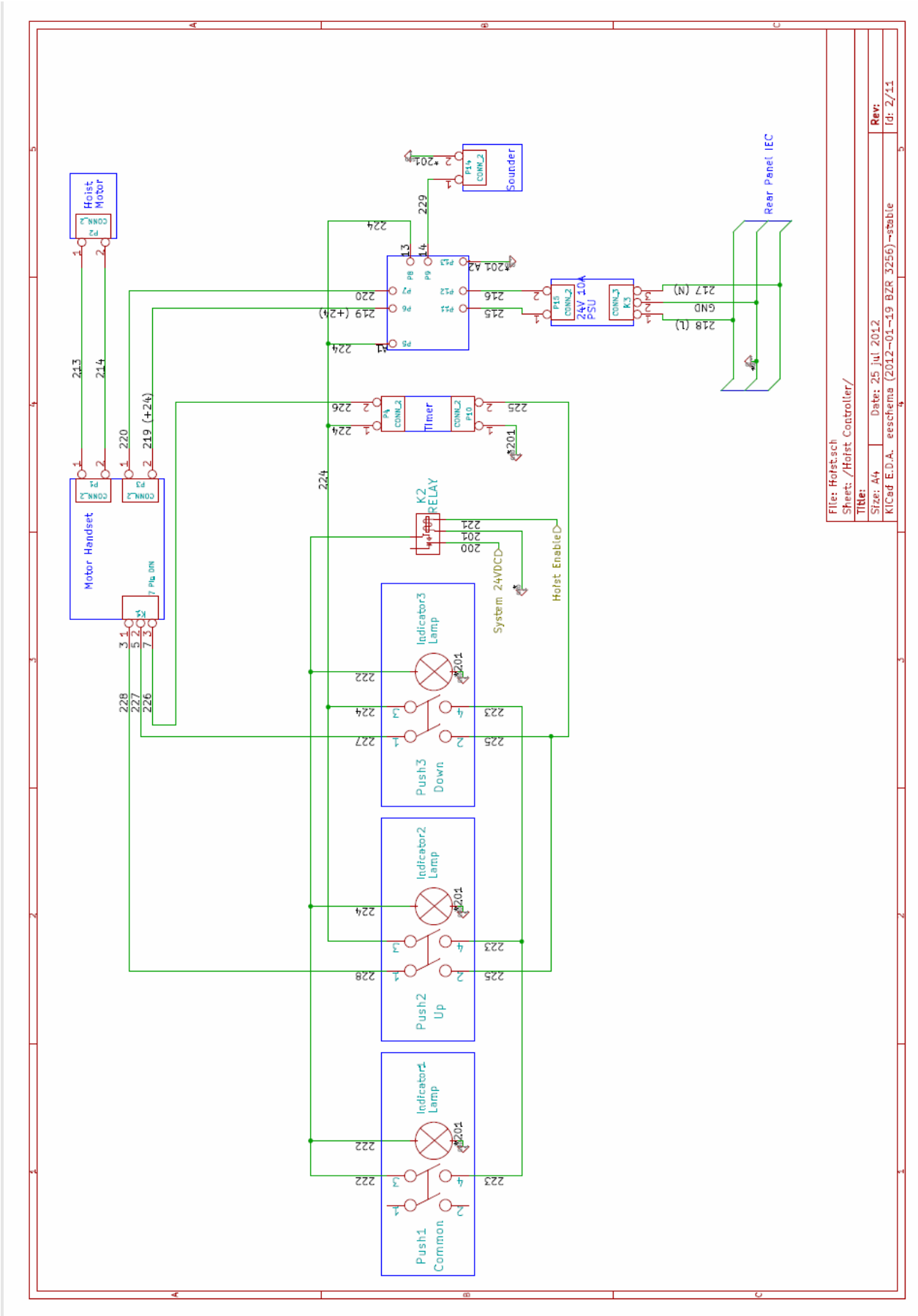
The RF VII Control Unit will be controlled by the computer under normal operations and will not require operator intervention. Should the advanced user by keen to use this manually they should discuss this requirement with TFSL, refer to the manufacturers manuals and conduct a risk assessment.

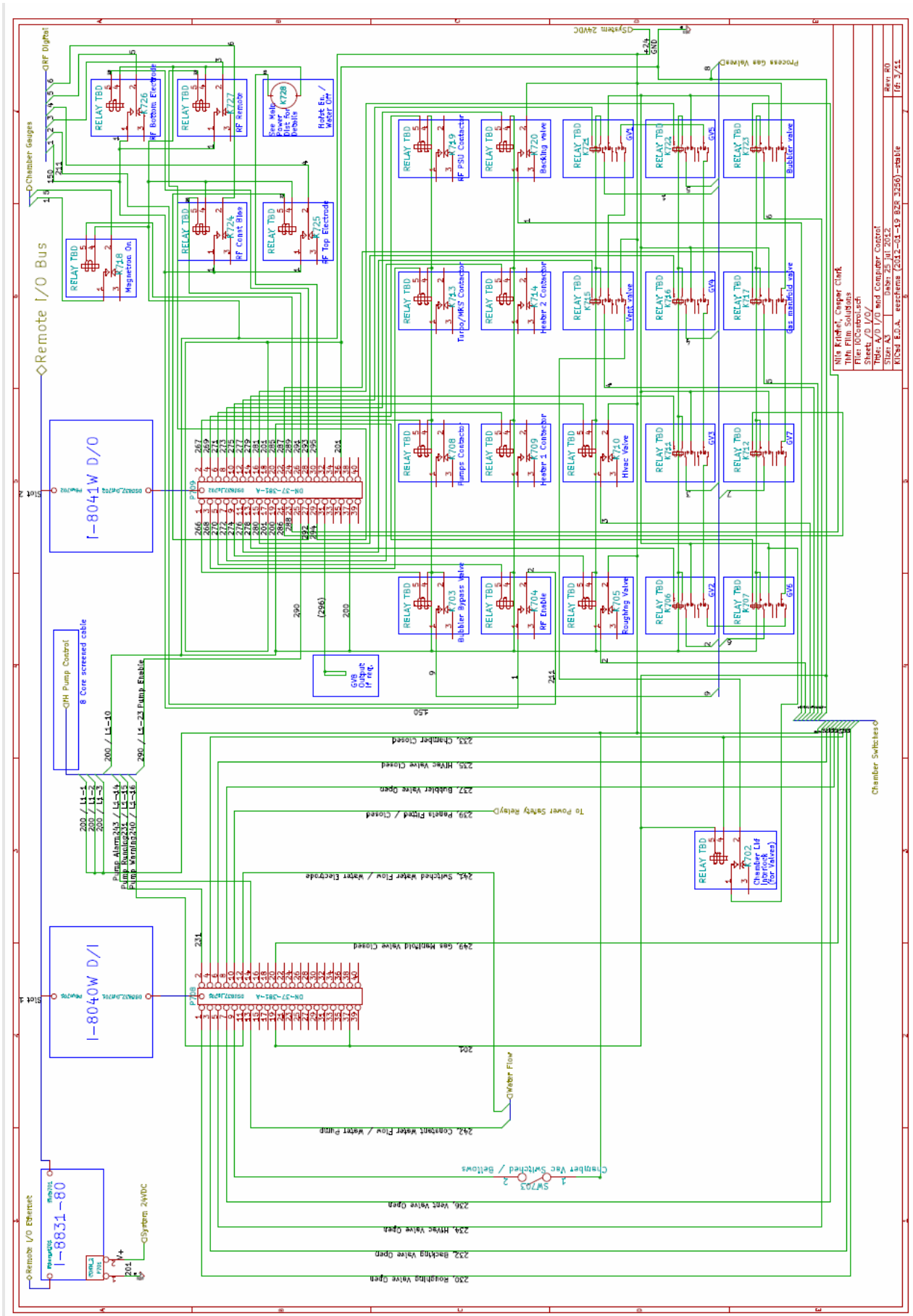
WARNING

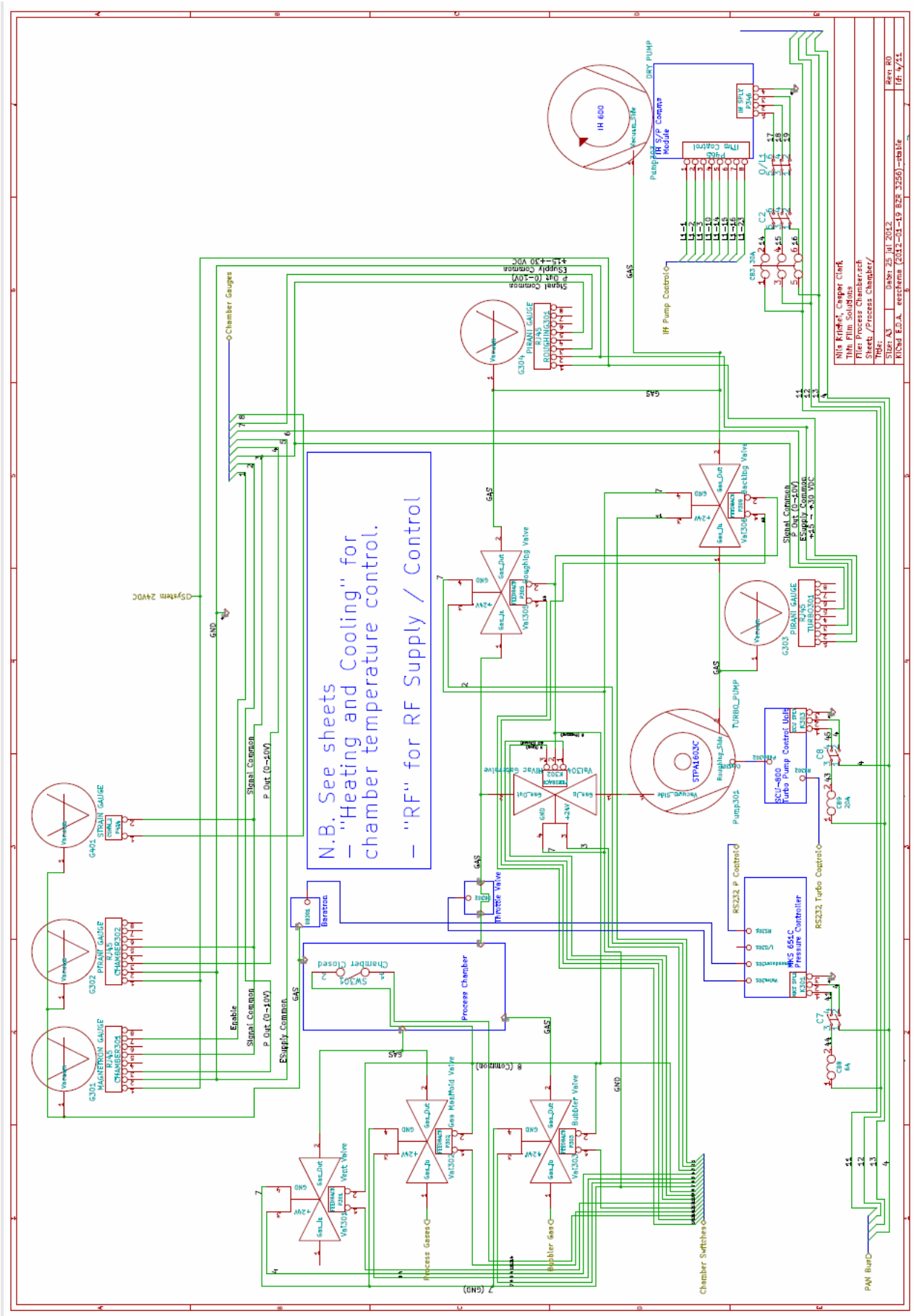
RF can cause serious burns or interference of sensitive electronic equipment, such as heart pacemakers. Do not operate the system unless all safety guidelines have been adhered to and all interlocks are in place.

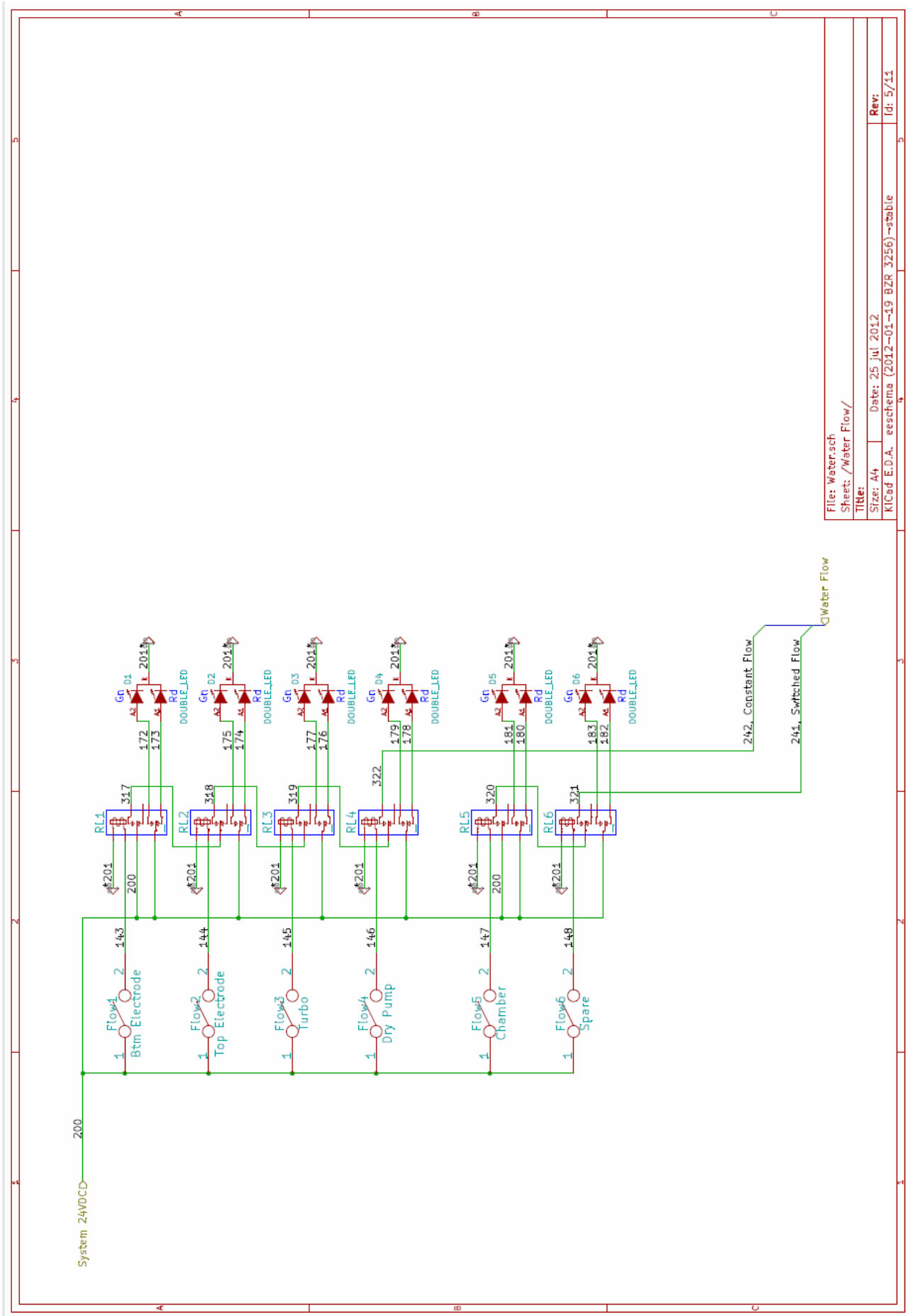
5.0 Electrical Drawings

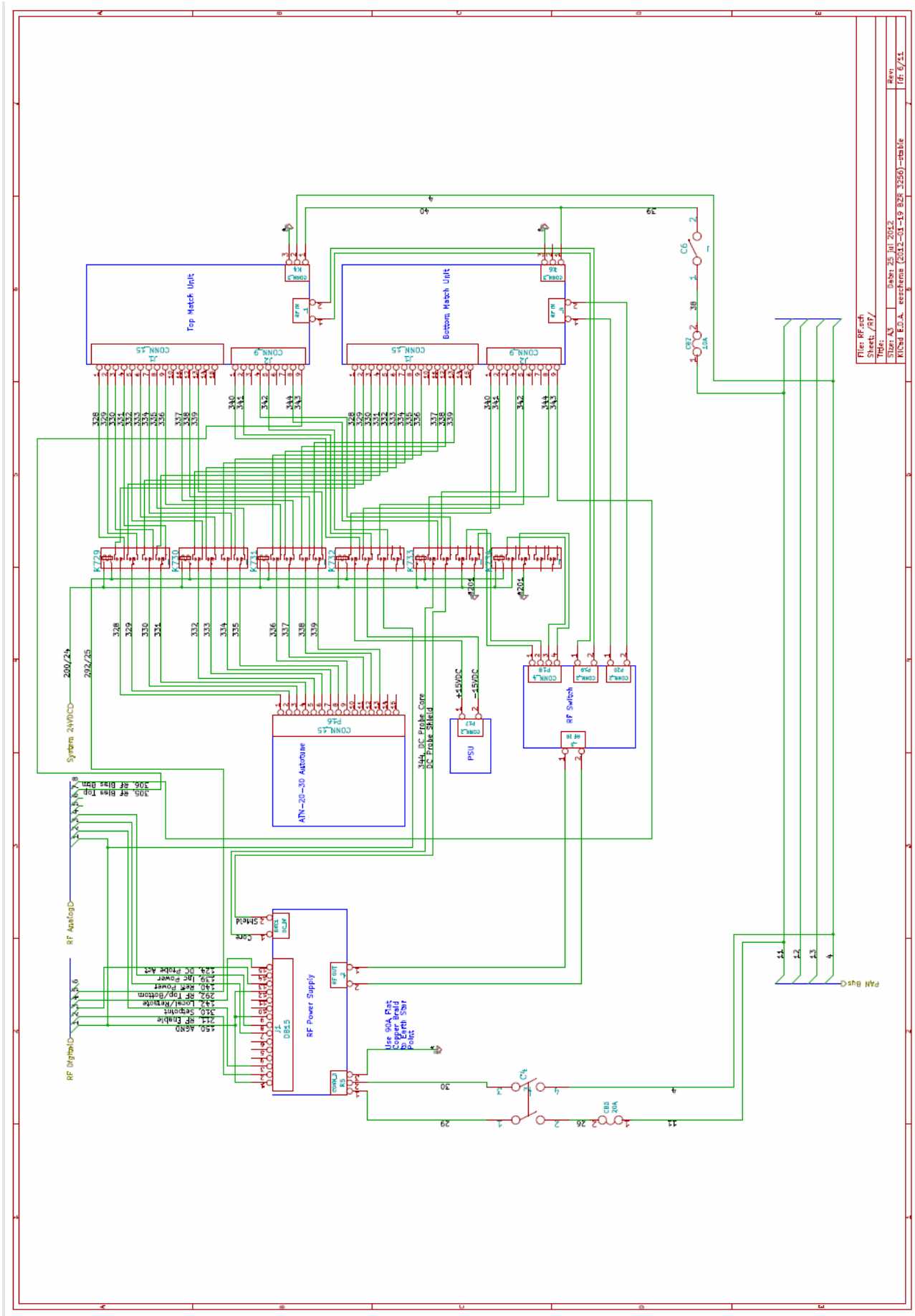


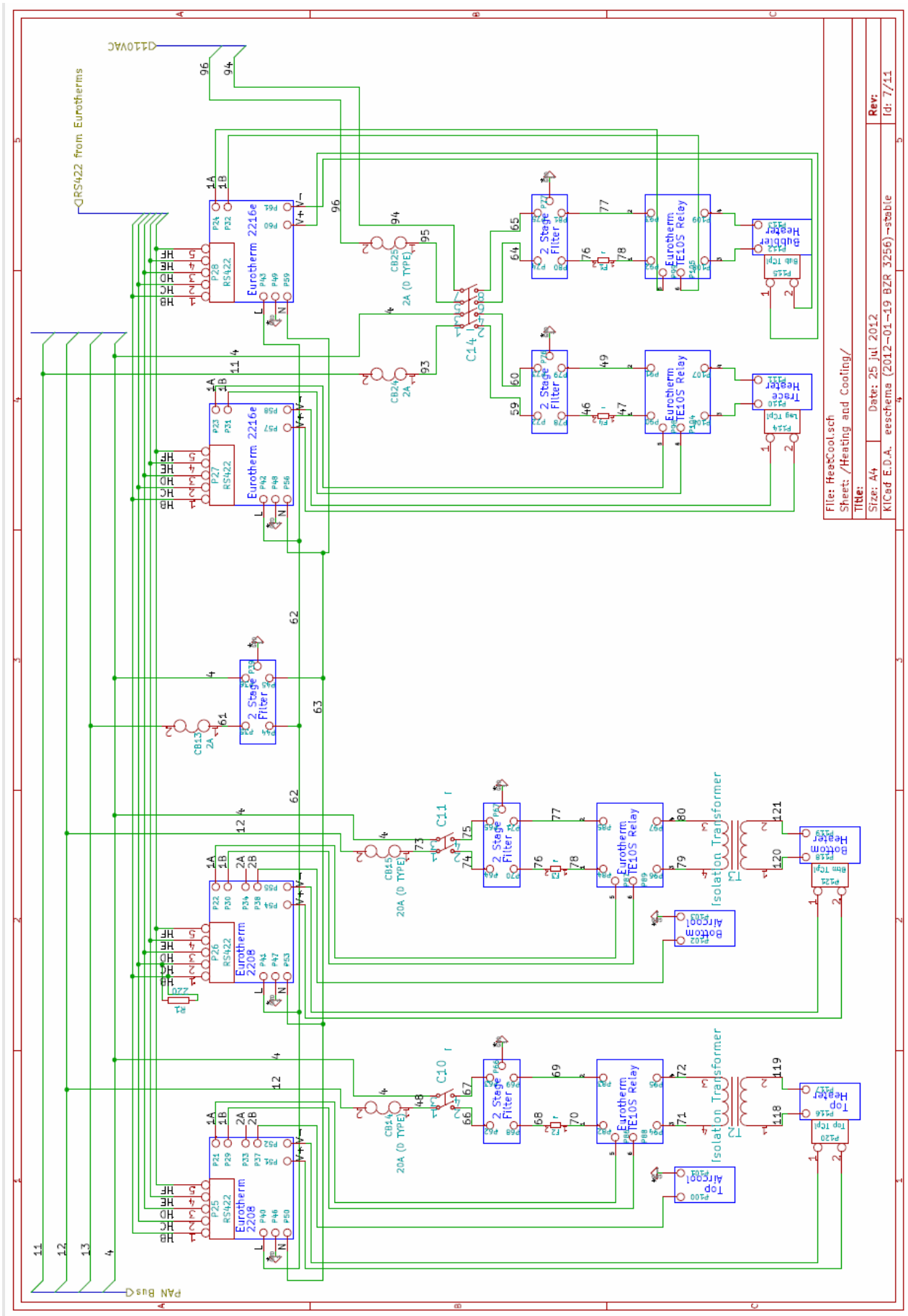

Hoist Motor
Sounder
Rear Panel IEC
24V 10A PSU
Timer
K2 RELAY
Motor Handset
Indicator3 Lamp
Push3 Down
Indicator2 Lamp
Push2 Up
Indicator1 Lamp
Push1 Common
System 24VDC
Hoist Enable
GND
File: Hoist.sch
Sheet: /Hoist Controller/
Size: A4
Date: 25 jul 2012
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable
Rev:
Id: 2/11

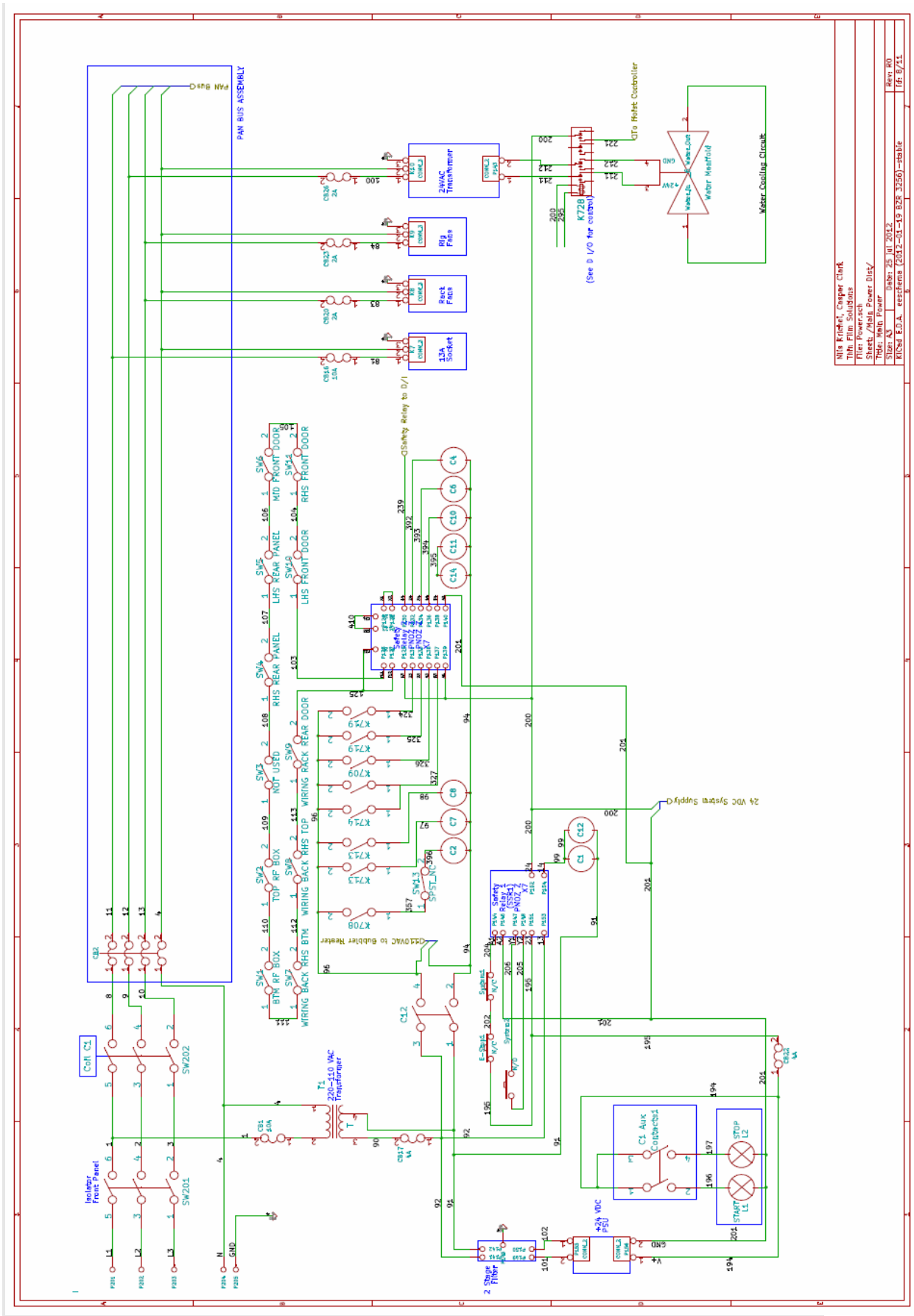

Remote I/O Bus
I-8041W D/O
I-8040W D/I
I-8831-80
Chamber Switches
Chamber Gauges
Process Gas Valves
Nils Kinkel, Casper Clark
Thin Film Solutions
Title: I/O Controlsch
Sheet: /3 I/O/
Title: A/D I/O and Computer Control
Size: A3
Date: 25 Jul 2012
KiCad E.D.A. eeschema (2012-03-19 BZR 3256)-stable
Rev: R0
Id: 3/11

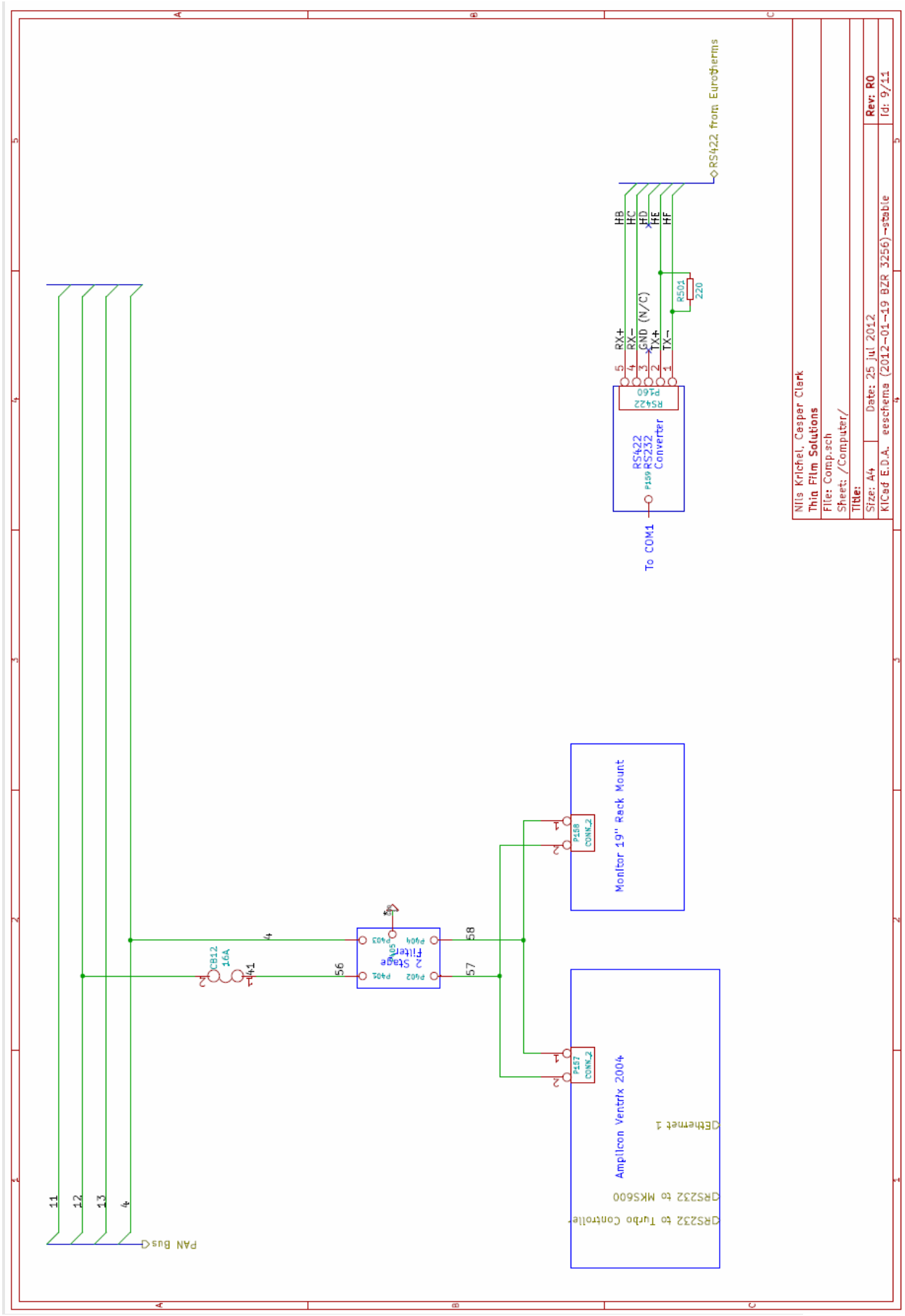

N.B. See sheets
– "Heating and Cooling" for
chamber temperature control.
– "RF" for RF Supply / Control
Nils Kristen, Casper Clark
Thin Film Solutions
File: Process Chamber.sch
Sheet: /Process Chamber/
Title:
Size: A3
Date: 25 jul 2012
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable
Rev: R0
Id: 9/11

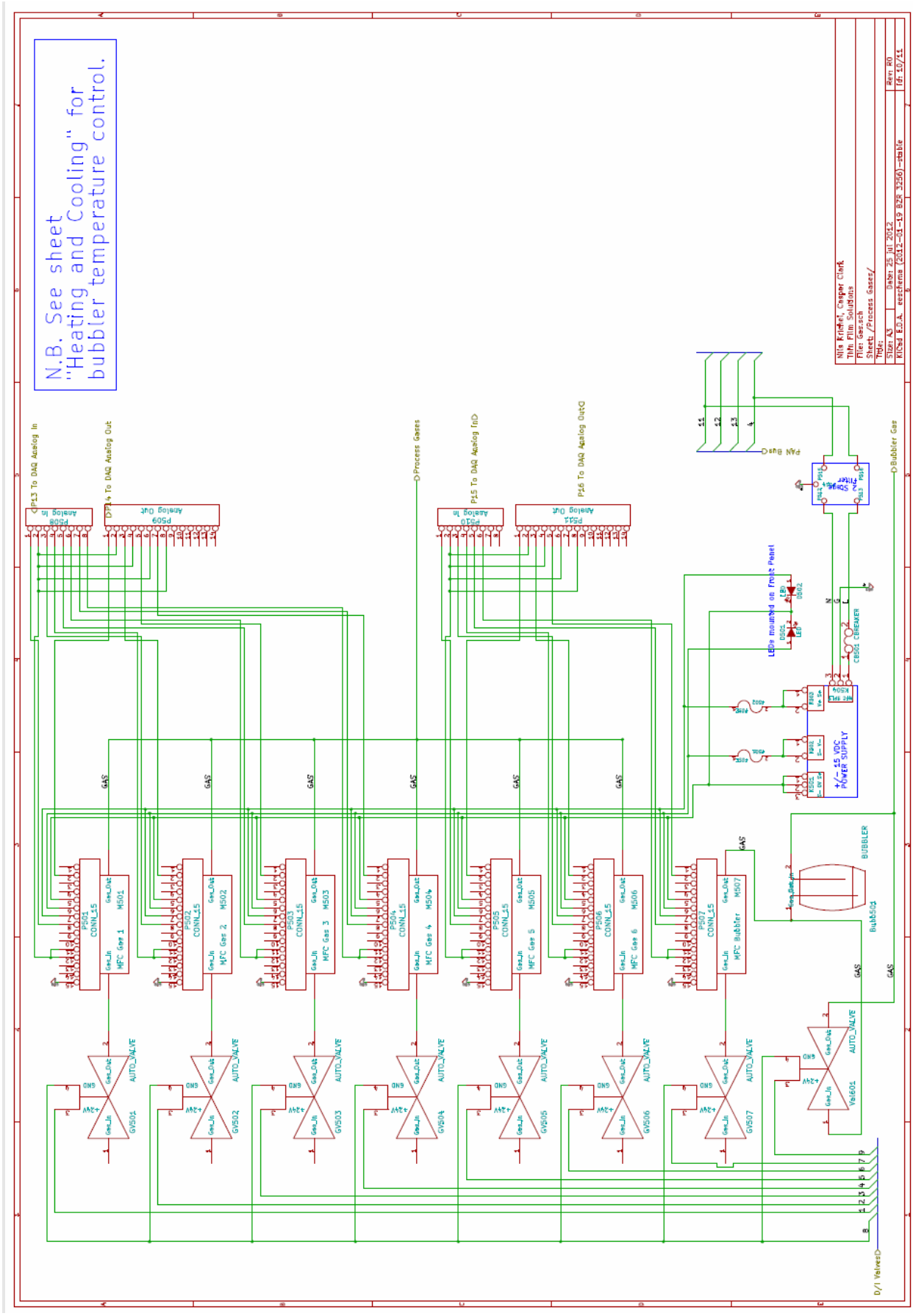

File: Water.sch
Sheet: /Water Flow/
Title:
Size: A4
Date: 25 jul 2012
Rev:
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable
Id: 5/11
Water Flow
242_Constant Flow
241_Switched Flow
System 24VDCD
200
RL1
RL2
RL3
RL4
RL5
RL6
317
318
319
322
320
321
Flow1
Btm Electrode
Flow2
Top Electrode
Flow3
Turbo
Flow4
Dry Pump
Flow5
Chamber
Flow6
Spare
D1
D2
D3
D4
D5
D6
DOUBLE_LED
Gn
Rd
A1
A2
K
201
172
173
175
174
177
176
179
178
181
180
183
182
143
144
145
146
147
148

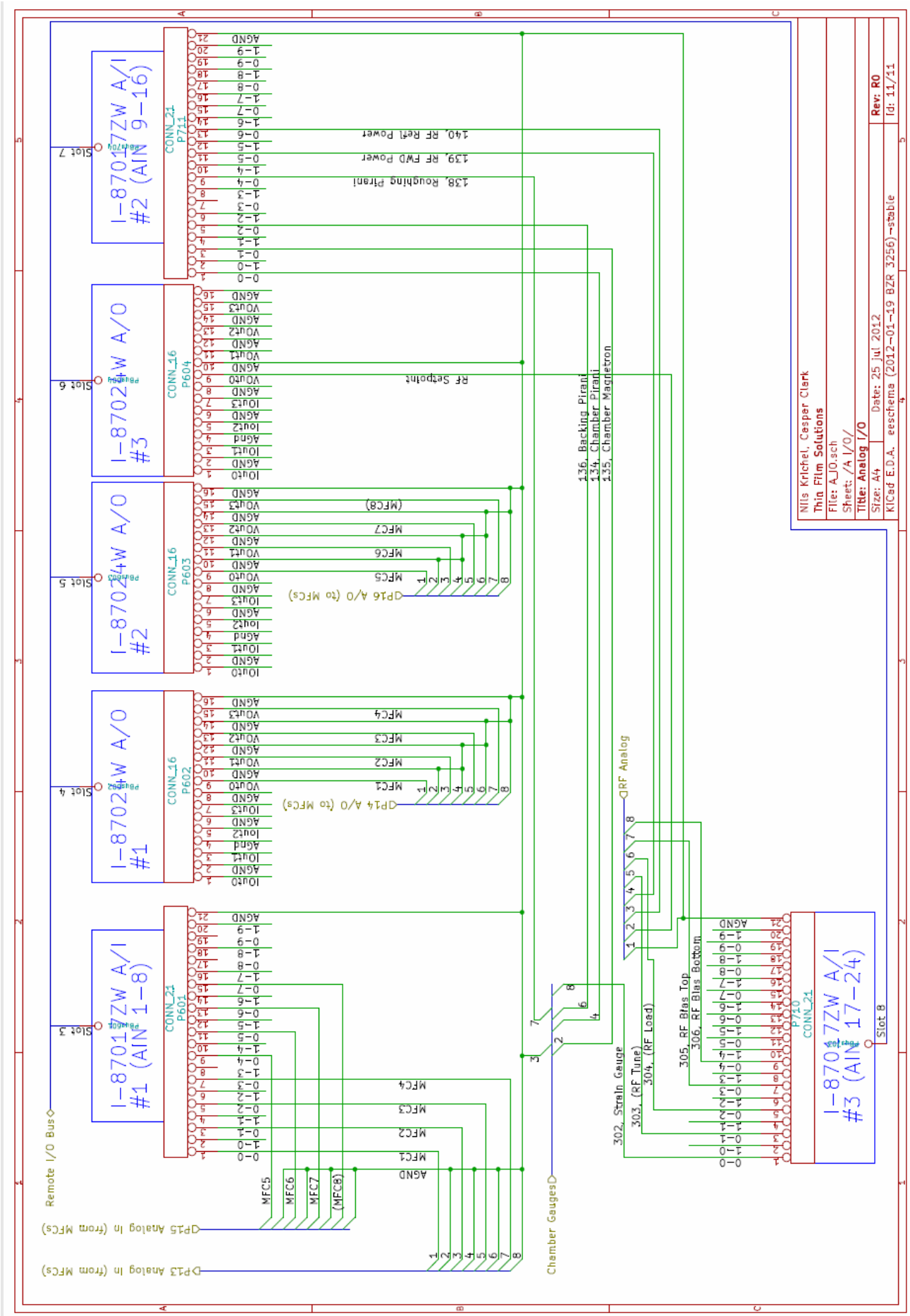

Top Match Unit
Bottom Match Unit
RF Switch
PSU
RF Power Supply
ATN-20-30 Automune
RF AnalogIO
RF DigitalIO
System 24VDCD
PAN Bus


Q110VAC
RS422 from Eurotherms
Eurotherm 2216e
Eurotherm 2208
2 Stage Filter
Eurotherm TE10S Relay
Bubbler Heater
Trace Heater
Bottom Heater
Top Heater
Isolation Transformer
PAN Bus
File: HeatCool.sch
Sheet: /Heating and Cooling/
Title:
Size: A4
Date: 25 jul 2012
Rev:
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable
Id: 7/11




RS422 from Eurotherms
HB
HC
HD
HE
HF
RX+
RX-
GND (N/C)
TX+
TX-
R501
220
RS422
RS232
Converter
To COM1
Monitor 19" Rack Mount
Amplicon Ventrfx 2004
Ethernet 1
RS232 to MKS600
RS232 to Turbo Controller
PAN Bus
CB12
16A
Stage
Filter
Nils Krichel, Casper Clerk
Thin Film Solutions
File: Comp.sch
Sheet: /Computer/
Title:
Size: A4
Date: 25 Jul 2012
Rev: RO
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable
Id: 9/11


N.B. See sheet
"Heating and Cooling" for
bubbler temperature control.
Nils Kriebel, Cooper Clark
Thin Film Solutions
File: Gas.sch
Sheet: /Process Gases/
Title:
Size: A3
Date: 25 Jul 2012
KiCad E.D.A. eeschema (2012-03-19 BZR 3256)-stable
Rev: R0
Id: 10/11
P513 To DAQ Analog In
P514 To DAQ Analog Out
P515 To DAQ Analog In
P516 To DAQ Analog Out
Process Gases
PAN Bus
Bubbler Gas
LEDs mounted on Front Panel
+/- 15 VDC POWER SUPPLY
BUBBLER
GAS
MFC Gas 1
MFC Gas 2
MFC Gas 3
MFC Gas 4
MFC Gas 5
MFC Gas 6
MFC Bubbler
AUTO_VALVE
D/I Valves


I-87017ZW A/I #2 (AIN 9-16)
I-87024W A/O #3
I-87024W A/O #2
I-87024W A/O #1
I-87017ZW A/I #1 (AIN 1-8)
I-87017ZW A/I #3 (AIN 17-24)
CONN_24 P711
CONN_16 P604
CONN_16 P603
CONN_16 P602
CONN_24 P601
P710 CONN_24
Slot 7
Slot 6
Slot 5
Slot 4
Slot 3
Slot 8
140, RF Refl Power
139, RF FWD Power
138, Roughing Pirani
RF Setpoint
136, Backing Pirani
134, Chamber Pirani
135, Chamber Magnetron
QP16 A/O (to MFCs)
QP14 A/O (to MFCs)
QRF Analog
305, RF Bias Top
306, RF Bias Bottom
304, (RF Load)
303, (RF Tune)
302, Strain Gauge
Chamber Gauges
Remote I/O Bus
QP15 Analog In (from MFCs)
QP13 Analog In (from MFCs)
MFC5
MFC6
MFC7
(MFC8)
MFC4
MFC3
MFC2
MFC1
AGND
Nils Krichel, Casper Clark
Thin Film Solutions
File: A_IO.sch
Sheet: /A I/O/
Title: Analog I/O
Size: A4
Date: 25 Jul 2012
Rev: R0
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable
Id: 11/11

6.0 Parameter Settings & Notes of Interest

6.1 Pressure Gauge Controller

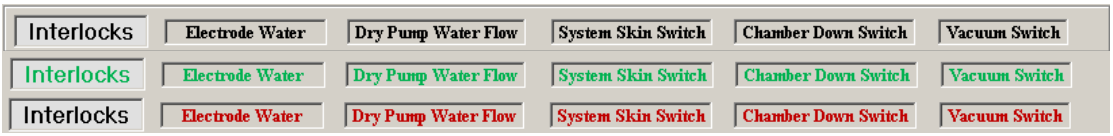
Changeover Pressure: This is the pressure (in mbar) during pump down at which the chamber ceases to be pumped directly by the dry pump and is then assisted by the turbo pump. The default is 5E-2 mbar.

Changeover Timeout: This is the time (in seconds) after which during pump down if the chamber has not achieved changeover pressure then the pumping sequence will cease. The default is 300s.

The set points should not be changed without discussing the consequences of any such changes on the system with Thin Film Solutions.

6.2 Interlocks

The P500+ is fitted with safety interlocks fitted for the protection of personnel and equipment. These should not be defeated under any circumstances. If the operation of these interlocks is not desirable then the issues should be discussed with Thin Film Solutions.



The state of an interlock is designated by the colour at the top of the software screen.

Before a pump can be activated the “Dry Pump Water Flow” interlock must be enabled. Before a process (automatic or manual) can be started all interlocks are required.

6.3 Hot Electrodes

When the chamber is vented after a high temperature process its important to ensure that sufficient time is allowed before switching off any cooling water circulation. Failure to do so may result in damage to seals and electrodes.

6.4 Safety Measures Provided

In addition to the interlocks mentioned in 6.2 there are feedback sensors on most valves; these are:
Vent Valve
High Vac Valve
Roughing Valve
Backing Valve
Gas Manifold Valve
Bubbler Isolation Valve

Gas line valves and the bubbler bypass valve do not have feedback sensors.

6.5 Chamber Door, Skin Guards

The chamber door is fitted with a mechanical switch which determines that the chamber is down and in the position where the hoist need no longer apply force.
Panel switches are in place to prevent the RF from being switched on whilst panels are missing from the chamber base.

6.6 Vacuum Interlock

When the chamber is under partial vacuum a bellows switch is made designating the vacuum interlock. No pressure inference can be made by this interlock only that it is below atmosphere. For a pressure reading the user is referred to the gauges.

6.7 Vacuum Valve & Pump Interlocks

Description	
Dry Pump	RF must be off Turbo must be off BV, RV, BBV must be closed Pump Water Interlock must be made
Turbo Pump	Dry Pump must be on Pump Water Interlock must be made
Roughing Valve	VV, HVV, BIV, GMV, BBV, BV must be closed Skin and Chamber Door Interlocks must be made
Vent Valve	RV,HVV,BIV,GMV must be closed
HiVac Valve	RV,VV,BIV,GIV must be closed Turbo must be on Chamber PI must be < changeover pressure
Bubbler Isolation Valve	VV must be closed Either RV or HVV must be open Dry Pump must be on
Bubbler Bypass Valve	BIV,HVV must be closed Dry Pump must be on
Gas Manifold Valve	VV must be closed Dry Pump must be on Either RV or HVV must be open
Gas Valve (gas channel # : 0-5)	VV must be closed GMV must be open Either RV or HVV must be open
Gas Valve (gas channel # : 6)	VV must be closed BIV must be open Either RV or HVV must be open
Backing Valve	RV,BBV must be closed Dry Pump must be on Roughing Line PI must be < 2.5

See page 34 for a description of valve names

6.8 Improper Methods of Operation that are Anticipated

In the automatic controlled mode of operation the equipment will be protected from certain improper modes of operation. For example, the programs in the PLC will ensure that the proper sequence of operation for the vacuum system is followed, etc. The equipment is not, however, protected from the inappropriate settings in automatic and manual controlled modes. For example it is possible to deliberately create conditions of high power dissipation in the sputtering targets that could lead to excessive heating of thermally sensitive targets. In manual mode basic hardwired safety interlocks will remain in force, however improper operation could still cause damage to the equipment, including the vacuum system.

CAUTION

Inappropriate equipment settings could result in damage. Ensure that processes are only changed and set by trained personnel.

CAUTION

Inappropriate equipment settings during manual operation could result in damage. Ensure that manual mode is only used by trained personnel.

Method of programming equipment, equipment required, programme verification, and additional safety procedures (where required)

The equipment is provided with a PLC that automates the sequencing of the vacuum control operations.

The control software installed in the PLC has been developed and validated by the manufacturer. This control programme must not be changed without TFS approval as the safety and functionality of the equipment could be compromised. No programming languages/facilities are provided with the equipment for these items.

The RF power supply and MKS controller are also individually programmable when the coatings system is operating in manual or automatic mode. Consult the power supply manufacturer's instruction manual before attempting to programme these.

7.0 Parameter Settings & Notes of Interest

7.1 Preventive Inspection Procedure

Regularly examine the electrodes for signs of damage including plasma etch and arc related defects. Inspect also the bubbler assembly and determine correct method of cleaning if required depending on the precursors used in a process. Always thoroughly clean between different precursors.

WARNING

Replace any damaged chamber windows immediately to minimise the potential implosion hazard.

7.2 Notes

- All ‘O’ rings should be removed and checked for damage and replaced if necessary, greased with the appropriate grease and carefully replaced into the groove.
- Ensure all mating faces are clean and free from scratches; small scratches should be removed by rubbing with fine emery paper.
- If disconnecting the water to a component we recommend you remove the lower connection first, place a container under this, and then slowly release the top connector. It is easier to catch most of the water this way.

WARNING

The combustion of dust generated during the deposition of certain materials is a potential explosion hazard. Stand clear of the chamber door when venting the vacuum chamber to air.

WARNING

Abrasive removal of titanium and similar metal residues may cause sparks.

WARNING

The residues/by-products from the deposition of certain materials may constitute a hazard to health. Ensure that the relevant risks of each have been appropriately assessed.

WARNING

Coated components will be heated by the process. Ensure that an appropriate risk assessment is carried out before handling.

WARNING

The high vacuum valves may operate without warning in the case of a power failure or loss of compressed air. Keep fingers and objects away from the opening of valves. Never touch moving parts.

7.3 Checking the Safety & Process Interlocks

The satisfactory operation of all safety and process interlocks should be checked regularly.

7.4 Leak Detection & Repair

The backing line is fitted with a manual isolation valve (Speedivalve) that can be used as a convenient place to connect a leak detector to the system.

If a vacuum seal is damaged or otherwise faulty a replacement seal should be fitted. If the defective seal is in one of the vacuum sub-systems then the appropriate original manufacturer's manual must be consulted.

WARNING

If any Viton™ fluoroelastomer seals are overheated, the decomposition products will include hydrofluoric acid.

7.5 Calibrating a Major Sub-System

To calibrate a major sub-system, such as a vacuum gauge, mass flow controller, high voltage power supply etc, always refer to the relevant manufacturer's instruction/maintenance manual.

7.6 Repairing a Major Sub-System

To repair a major sub-system, such as a vacuum pump, high voltage power supply, motor drive, etc, always refer to the relevant manufacturer's instruction/maintenance manual. If anything is unclear or if you wish assistance please contact TFS.

7.7 Recommendations on maintenance/service records

Review the instruction manuals for the major sub-systems (e.g. vacuum pumps, gauges, etc) for recommended maintenance procedures and frequency of maintenance.
The chamber 'O' ring should be wiped clean to remove any dust on the sealing face every time that the chamber is opened.

7.8 Weekly Checks

- Visual inspection for leaks and general condition

- Check interlock operation

7.9 Monthly Checks

- Clean vacuum chamber

Appendix A Risk Assessment

Risk Assessment

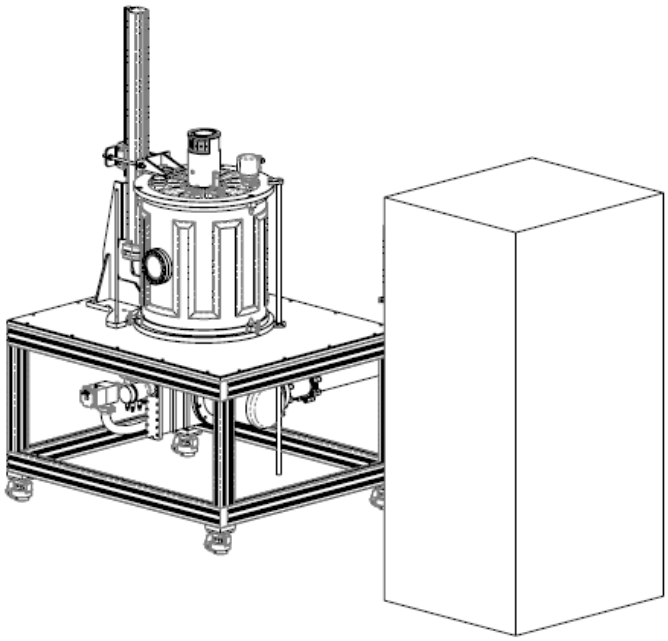
Good working practice encourages the use of detailed risk assessment. These should be completed by qualified personnel and reviewed regularly.

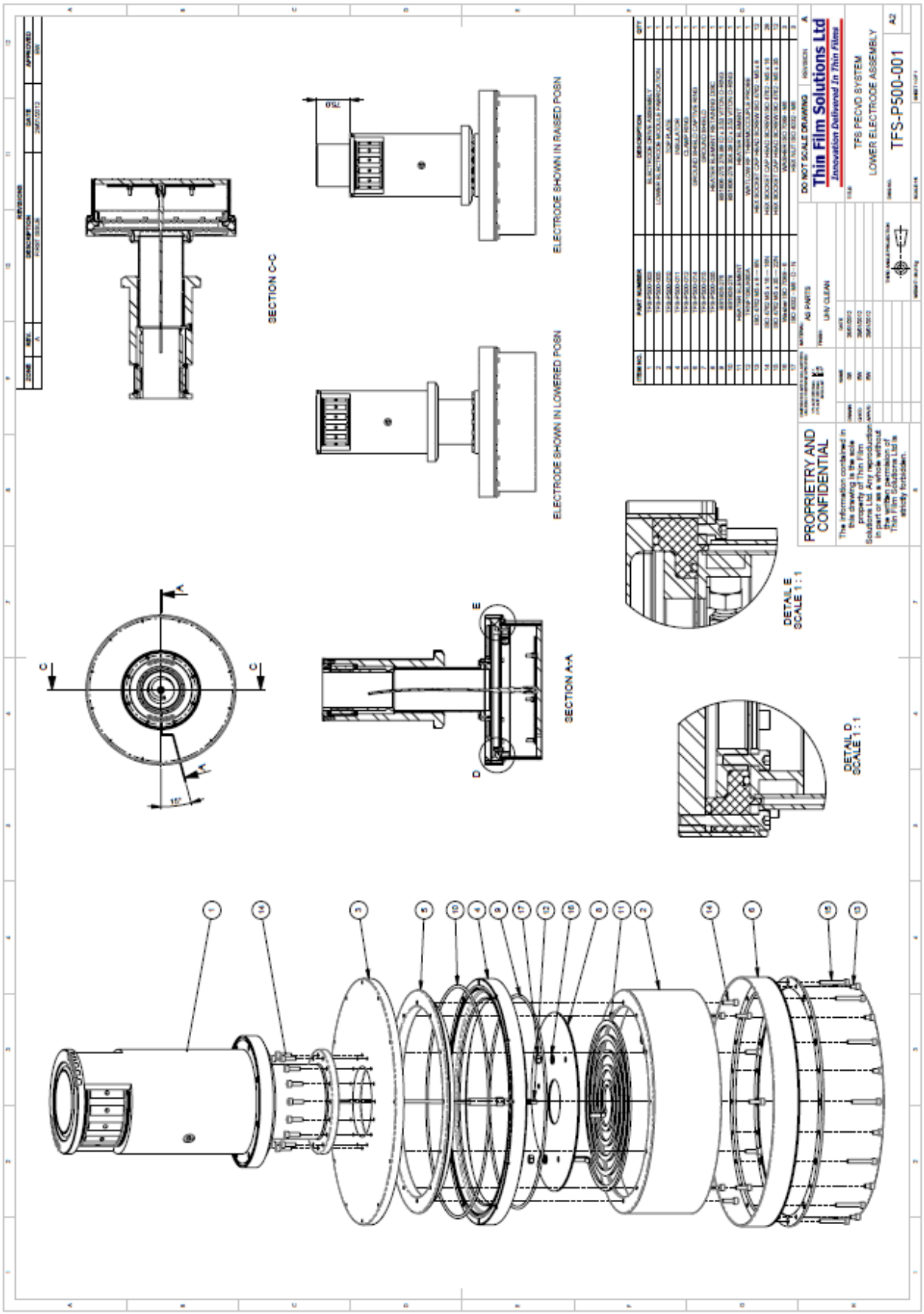
Organisation name:
Risk Assessor:
Assessment Date:

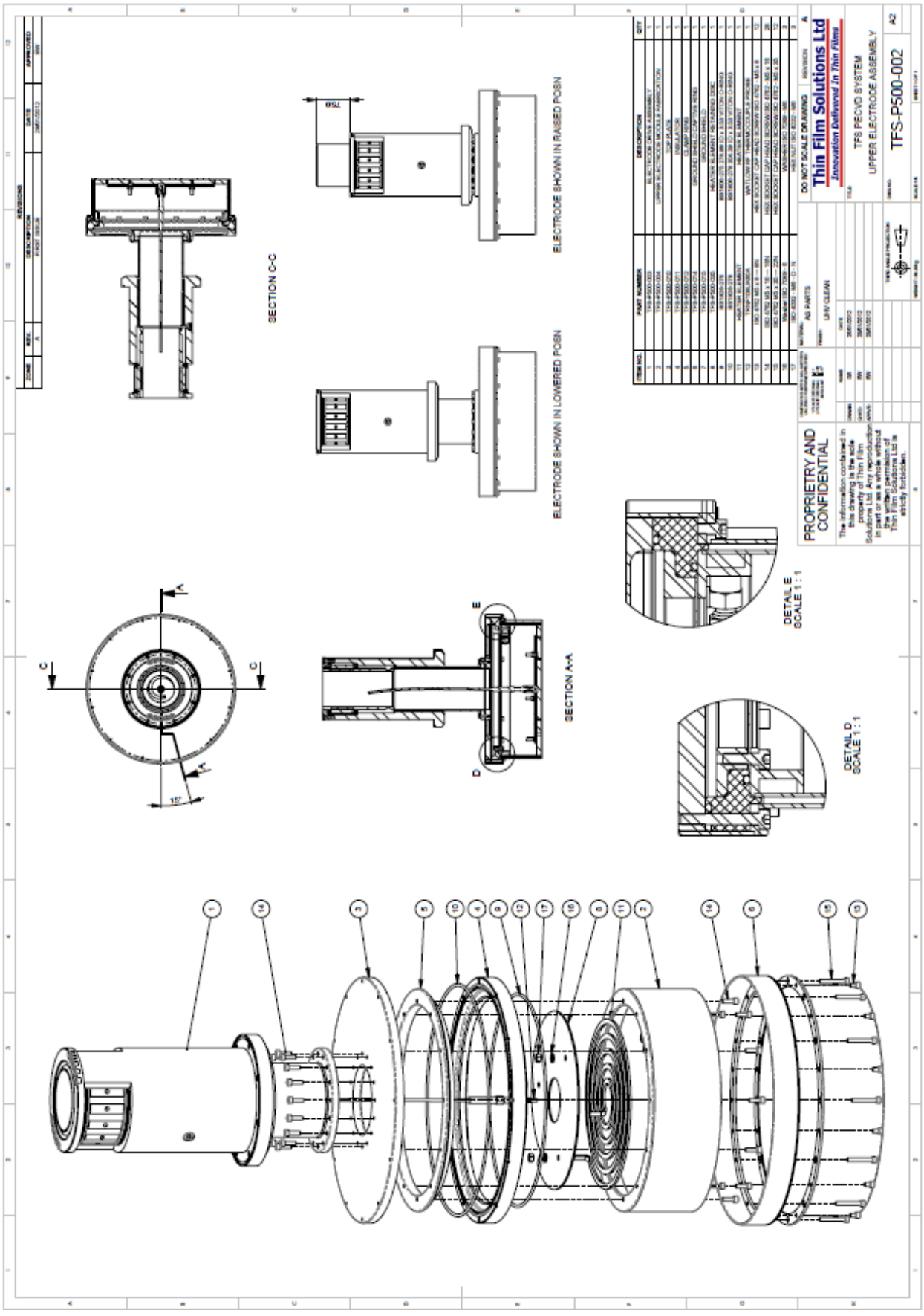
What are the hazards?	Who might be harmed and how?	What are you already doing?	Do you need to do anything else to manage this risk?	Action by whom?	Action by when?	Done
EXAMPLE Slips and trips	*Staff and visitors may be injured if they trip over objects or slip on spillages*	*We carry out general good housekeeping. All areas are well lit including stairs. There are no trailing leads or cables. Staff keep work areas clear, e.g. no boxes left in walkways, deliveries stored immediately, offices cleaned each evening*	*Better housekeeping is needed in maintenance corridor / service chase, e.g. on spills*	*All staff, supervisor to monitor*		

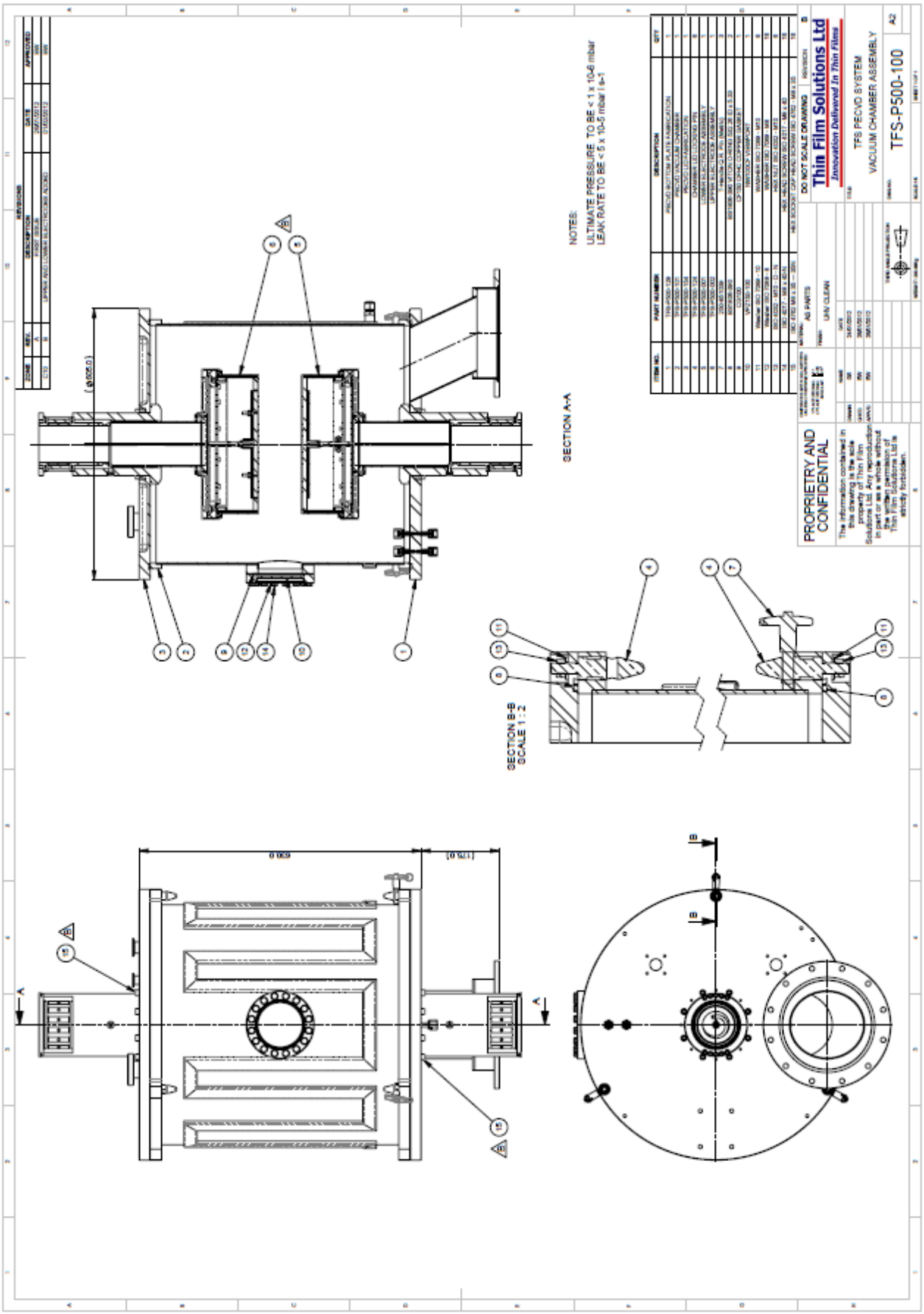
Appendix B Parts List

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	TFS-P500-100	VACUUM CHAMBER ASSEMBLY	1
2	TFS-P500-200	HEAT SHIELD ASSEMBLY	1
3	TFS-P500-303	DRY PUMP EXTENSION TUBE	1
4	TFS-P500-304	DRY PUMP BELLOWS	1
5	TFS-P500-305	DRY PUMP S-BEND	1
6	TFS-P500-400	FRAME ASSEMBLY	1
7	TFS-P500-500	HOIST ASSEMBLY	1
8	TFS-P500-507	CHAMBER HOIST STEADY ASSEMBLY	1
9	653B-8-200-2	MKS EXHAUST THROTTLE VALVE, NON SEALING ISO 200	1
10	TFS-P500-301	PUMPING TEE PIECE	1
11	B65551000	EDWARDS GVI200P GATE VALVE	1
12	B426-03-000	EDWARDS QUATER SWING BUTTER FLY ISOLATION VALVE	1
13	P046----Z107-4		1
14	ISO100-AV ISO200	SEALING RING ASSEMBLY	6
15	ISO200-AV ISO200	SEALING RING ASSEMBLY	4
16	A59020001	EDWARDS IH600 DRY PUMP	1
17	TFS-P500-302	ROUGHING MANIFOLD	1
18	ISO-TC	ISO-K FLANGE TOP CLAMP	8
19	C10516395	KF40 CENTRING RING	5
20	KTR40-25	KF40-KF25 REDUCER TEE	2
21	C10514395	KF25 CENTRING RING	5
22	D02602000	APG100 NW25	3
23	C33255000	SPEEDIVALVE SP16K VITON	1
24	KTR25-16	KF25-KF16 REDUCER TEE	1
25	C10512395	KF16 CENTRING RING	3
26	C41415000	PV40PKS NW40 PNEUMATIC VALVE	1
27	KF40	FLEX HOSE	1
28	C10512403	NW10/16KF Swing Clamp	3
29	C10514403	KF25 CLAMP	5
30	C10516403	KF25 CLAMP	5
31	C10007156 I	SO63-100 EDWARDS CLAW CLAMP	24
32	Washer ISO 7089 - 8	WASHER ISO 7089 - M8	16
33	ISO 4032 - M8 - D - N	HEX NUT ISO 4032 - M8	8
34	ISO 4017 - M8 x 80-N	HEX HEAD SCREW ISO 4017 - M8 x 80	8
35	ELECTRONICS RACK	PECVD ELECTRONICS RACK	1
36	D14641000	AIM S NW25	1
37	D05915000	VACUUM SWITCH ADJUSTABLE VS16K	1
38	NW35CF-B	CF70-38	1




SECTION C-C
ELECTRODE SHOWN IN RAISED POSN
ELECTRODE SHOWN IN LOWERED POSN
SECTION A-A
DETAIL E
SCALE 1 : 1
DETAIL D
SCALE 1 : 1
PROPRIETRY AND CONFIDENTIAL
Thin Film Solutions Ltd
Innovation Delivered In Thin Films
TFS PECVD SYSTEM
LOWER ELECTRODE ASSEMBLY
TFS-P500-001
A2


SECTION C-C
ELECTRODE SHOWN IN RAISED POSN
ELECTRODE SHOWN IN LOWERED POSN
SECTION A-A
DETAIL E
SCALE 1 : 1
DETAIL D
SCALE 1 : 1
PROPRIETRY AND CONFIDENTIAL
Thin Film Solutions Ltd
Innovation Delivered In Thin Films
TFS PECVD SYSTEM
UPPER ELECTRODE ASSEMBLY
TFS-P500-002


NOTES:
ULTIMATE PRESSURE TO BE < 1 x 10-6 mbar
LEAK RATE TO BE < 5 x 10-5 mbar l s-1
SECTION A-A
SECTION B-B
SCALE 1 : 2
Thin Film Solutions Ltd
Innovation Delivered in Thin Films
TFS PECVD SYSTEM
VACUUM CHAMBER ASSEMBLY
TFS-P500-100
PROPRIETRY AND CONFIDENTIAL
DO NOT SCALE DRAWING

O-RING REQUIREMENT FOR THE PECVD SYSTEM				NAME			
PART No	DESCRIPTION	TOTAL QTY	WHERE USED				
BS1806-390	VITON O-RING 532.26 ID x 5.33	2	TFS-P500-100	VACUUM CHAMBER ASSEMBLY			
BS1806-276	VITON O-RING 278.99 ID x 3.53	2	TFS-P500-001, TFS-P500-002	LOWER ELECTRODE ASSEMBLY,			
BS1806-278	VITON O-RING 304.39 ID x 3.53	2	TFS-P500-001, TFS-P500-002	UPPER ELECTRODE ASSEMBLY			
BS1806-242	VITON O-RING 101.19 ID x 3.54	2	TFS-P500-003	ELECTRODE DRIVE ASSEMBLY			
BS1806-262	VITON O-RING 164.69 ID x 3.55	2	TFS-P500-003	ELECTRODE DRIVE ASSEMBLY			
BS1806-241	VITON O-RING 98.02 ID x 3.56	2	TFS-P500-003	ELECTRODE DRIVE ASSEMBLY			
	VITON O RING 25.07 ID 2.62 thick	1	TFS-B100-001	BUBBLER ASSEMBLY			

Appendix C Miscellaneous Wiring Data