

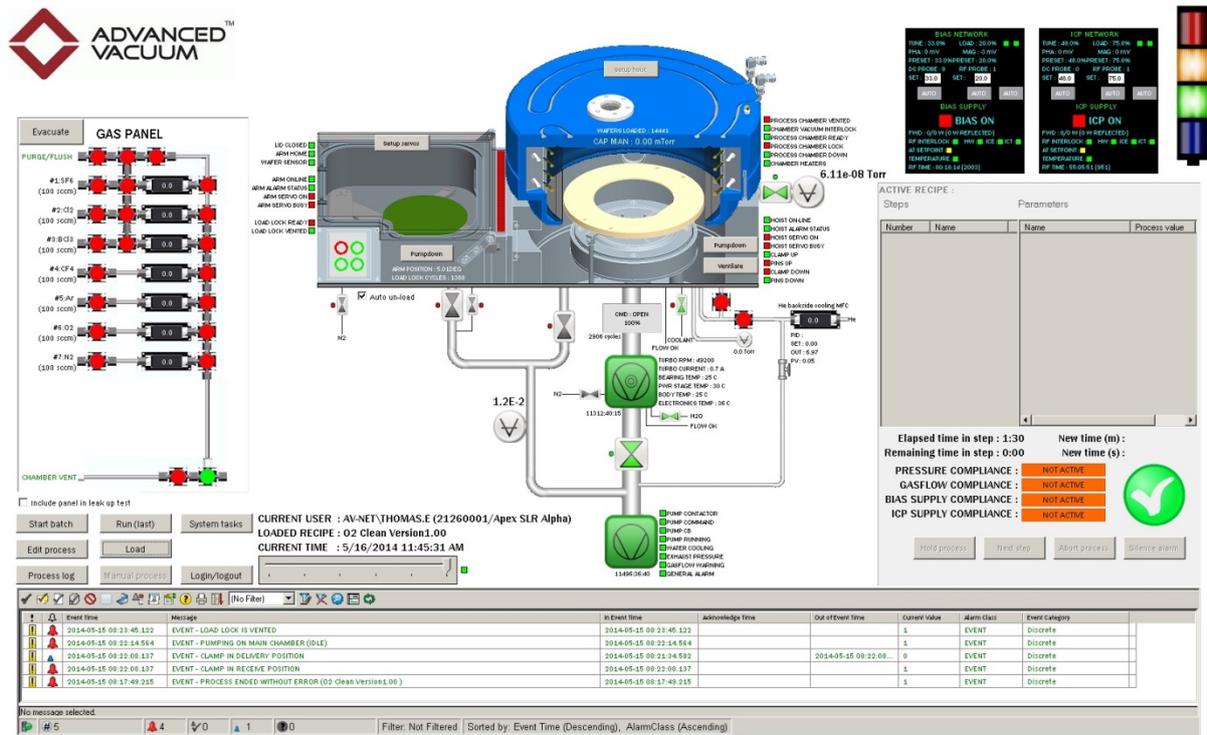
# F-ICP Operation

## APEX SLR ICP



# Using the "Main" screen

The "Main" screen is the main operator interface. This is where all major functions are accessed, and also where process recipes are edited, and executed from.



"Main" screen

The main functions that are used on a daily bases are all included within this one screen. They are the following functions and these are the buttons they are connected to.



Load lock with load lock control panel

## Load a wafer without process start

- ✓ Ensure there is no wafer in process module
- ✓ Open load lock lid
- ✓ Load wafer onto load lock arm end effector (ensure flat and position is within the designed area on the end effector)

- ✓ Close load lock lid
- ✓ Push the "LOAD/UNLOAD" button on the load lock control panel or alternatively click on the "LOAD" button on the machine interface.

### Load a wafer with process start (pre-loaded recipe)

- ✓ Ensure there is no wafer in process module
- ✓ Open load lock lid
- ✓ Load wafer onto load lock arm end effector (ensure flat and position is within the designed area on the end effector)
- ✓ Close load lock lid
- ✓ Push the "RUN" button on the load lock control panel or alternatively click on the "Run (last)" button on the machine interface.

### Load a wafer and run a new process

- ✓ Ensure there is no wafer in process module
- ✓ Open load lock lid
- ✓ Load wafer onto load lock arm end effector (ensure flat and position is within the designed area on the end effector)
- ✓ Close load lock lid
- ✓ Click on "Start batch" on the machine interface.
- ✓ Select the desired process.
- ✓ Click "Start"

### Unloading a wafer

The procedure below assumes that the process module has a wafer loaded into it.

- ✓ Ensure there is no wafer on the load lock arm end effector
- ✓ Push the "LOAD/UNLOAD" button on the load lock control panel or alternatively click on the "UNLOAD" button on the machine interface.

If the "Auto unload" checkbox is checked (adjacent to the load lock mimic on the machine interface) the wafer will automatically unload following a process (regardless of process outcome).

### Main screen appearance when transferring wafers

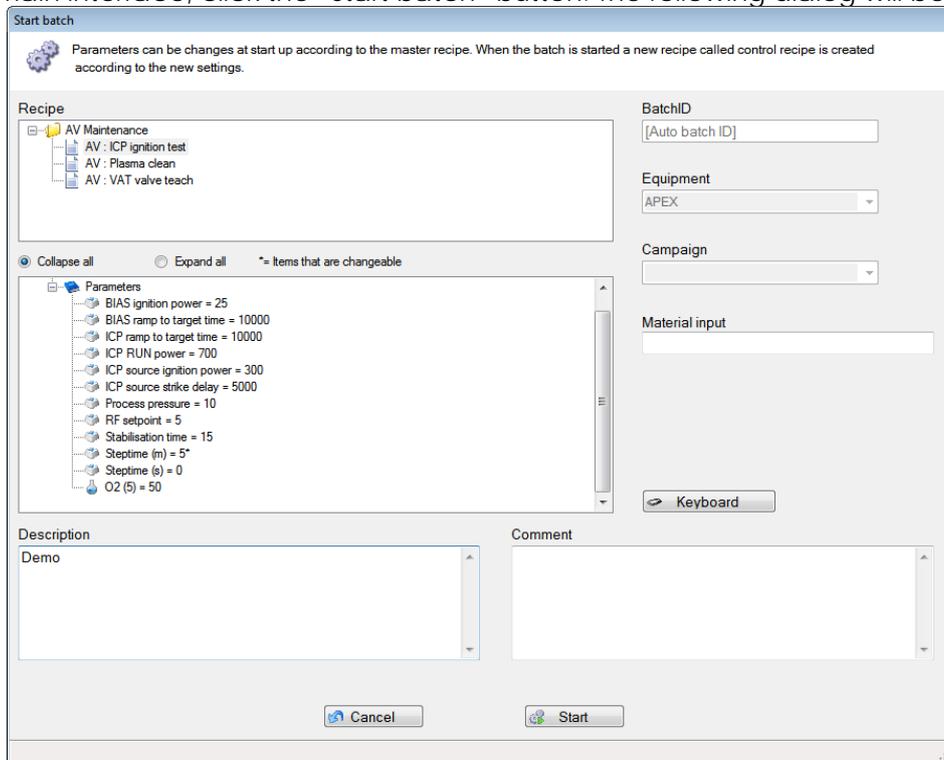
The screenshot shows the main interface of the Advanced Vacuum system. At the top left is the logo. The central part features a 3D diagram of the chamber with a wafer being loaded. To the left is a 'GAS PANEL' with various valves and gauges. On the right, there are several status indicators and controls, including 'BIAS NETWORKS', 'BIAS SUPPLY', and 'IDP NETWORKS'. The current pressure is displayed as 0.0015 Torr. Below the chamber diagram, there are system tasks and user information: 'CURRENT USER : av (2400102/JPL)', 'LOADED RECIPE : AV : Plasma clean Version1.00', and 'CURRENT TIME : 9/12/2014 11:52:43 AM'. At the bottom, there is an event log table.

Event Time	Message	In Event Time	Acknowledge Time	Out of Event Time	Current Value	Alarm Class	Event Category
9/12/2014 11:52:37.423	EVENT - WAFER IS BEING LOADED INTO CHAMBER	9/12/2014 11:52:37.42			S	EVENT	Discrete
9/12/2014 11:52:34.799	EVENT - LOAD LOCK IS VERIFIED	9/12/2014 11:51:14.79			S	EVENT	Discrete
9/12/2014 11:50:30.905	EVENT - ENTERING LOAD LOCK	9/12/2014 11:50:30.90			S	EVENT	Discrete
9/12/2014 11:50:48.838	EVENT - CLOSING SUITVALVE	9/12/2014 11:50:48.84			S	EVENT	Discrete
9/12/2014 11:50:43.073	EVENT - CLAMP IN RECEIVE POSITION	9/12/2014 11:50:43.07			S	EVENT	Discrete

During the wafer movement, the screen shows where the wafer is, and whether it is going in or out of the process chamber.

### Automatic process run

From the main interface, click the "Start batch" button. The following dialog will be shown.

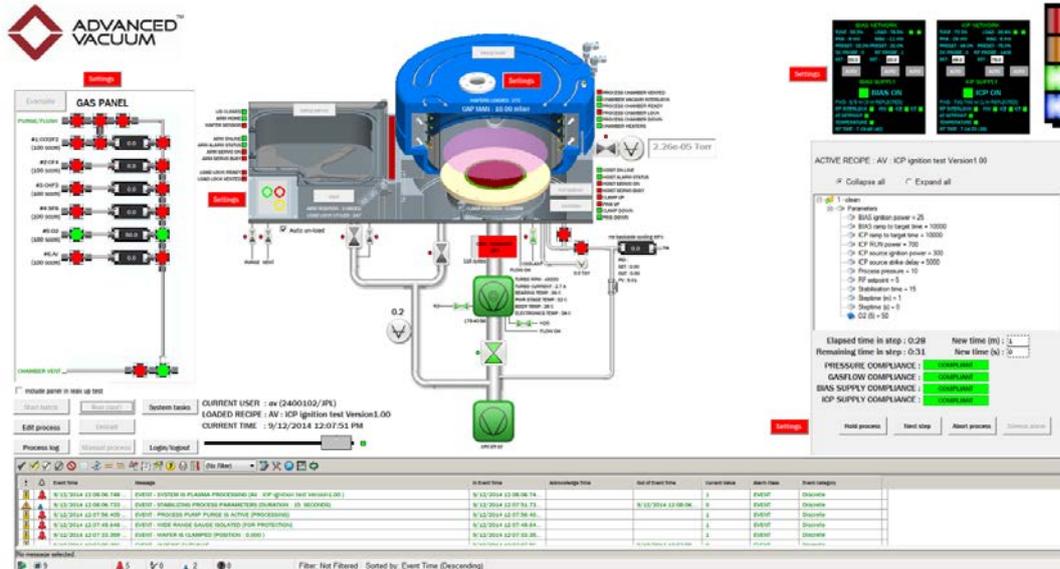


Main screen – Start process dialog

In the top left area, the various categories and recipes are listed. To expand a process category, click the "+" next to the desired category.

In the expanded view select the process you wish to execute, if any changes are to be made to the parameters that are able to change (see section in creating recipes) they should be made now. Items that have a "\*" next to them are changeable, and can be modified for the run by double clicking on the actual parameter. This can be done for parameters in each independent step. After this, click "Start" and the batch recipe will loaded to the PLC and executed.

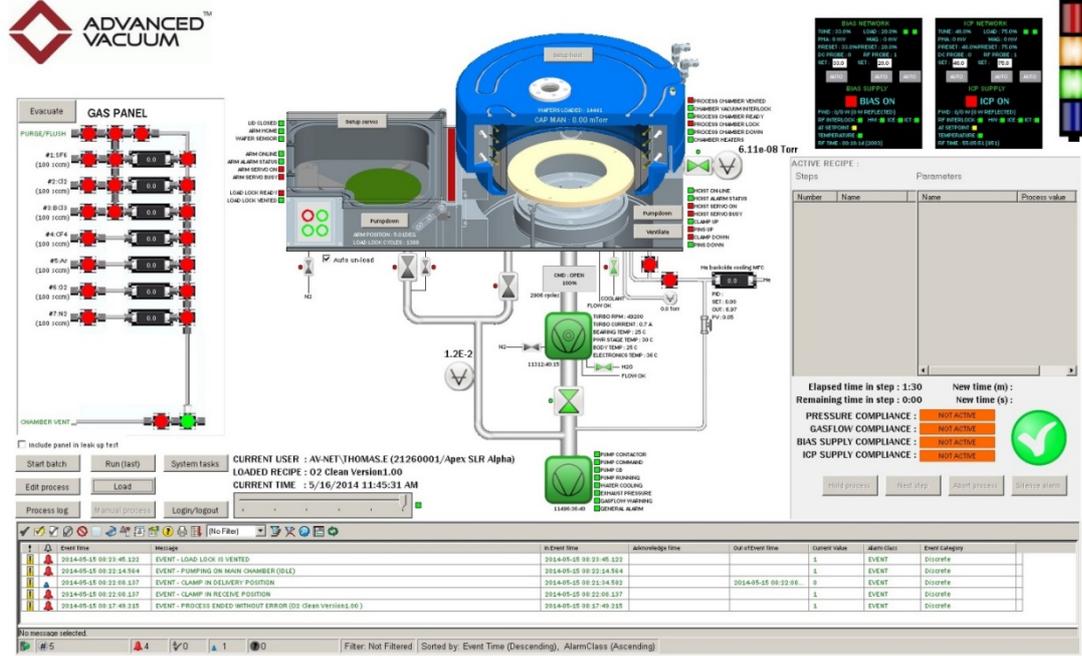
The appearance of the operator screen will at this point also change appearance.



Main screen – Plasma process

The above window shows a standard ICP process, with both the ICP and Bias generator running (in green).

When the process has completed (without error) the screen will be shown as on next side.



Main screen – Process ended OK

When the process has finished, without error, there is a green checkmark in the process window. The event/alarm window will also display "EVENT – PROCESS ENDED WITHOUT ERROR (recipename)".

### Automatic process run with process hold due to parameter error

If an error (process gas flow, pressure regulation) occurs during the process, again, depending on how the tool has been configured the tool response will vary.

If the tool has been set up not to hold on a process error, the process will abort, and render a "Process failed" report. If however the tool has been set up to hold on a process error, the main screen will show PROCESS HOLD in the event/alarm window and the button "Release hold" will be active.

There is a button right to the chamber dialog showing "Release hold" (will show "Hold process" when no error is present and process is running normal). The hold will only be released if/when the process parameter that is out of compliance is again within compliance. Any "Release hold" will be unsuccessful prior to that. If the system has been set up for automatic process hold reset, the system will automatically release the process hold when the process parameter is within compliance again.

If the process is returned to normal, the process will execute and terminate normal. The parameter producing the error will be logged into the log file, but the process will be registered as a completed process without failure. If the abort button is clicked when the process hold occurs, the process will abort with a process failure report instead.

### Automatic process run ending with error

If the process runs into a problem that can not be resolved (i.e. process gas runs out, etc) the process will be registered as a "failed process". The operator screen will also reflect this at the conclusion of the process by putting a red "x" in the process window.

The screenshot displays the main control interface for an Advanced Vacuum system. The central part of the screen shows a 3D cutaway view of the chamber with various parameters like pressure (3.25e-07 Torr) and chamber status. On the left, there's a 'GAS PANEL' with various gas flow controls. On the right, there's an 'ACTIVE RECIPE' section with a table of steps and parameters. Below that, a status bar shows compliance levels for pressure, gasflow, bias supply, and ICP, all marked as 'NOT ACTIVE'. At the bottom, an event log shows a recent message: 'EVENT - PUMPING DOWN LOAD LOCK'.

Main screen – Process failed

### **User requested process hold during process execution**

The operator can choose to activate a process hold during the execution of the process. To do this, click the "Process hold" button next to the chamber icon on the screen. The process hold will turn off all plasma sources, but keep gases flowing and maintaining the requested process pressure. To release the hold click the "Release hold" button.

## **Creating and editing recipes**

### **General**

A General recipe is the base for all recipes. It contains e.g. default parameters and limitations for the parameters. The General recipe (which is set up at the factory) cannot be changed.

When a new recipe is created, the General recipe is copied and used as base. The new recipe is called a Master recipe. The only thing the user will see is the Master recipe.

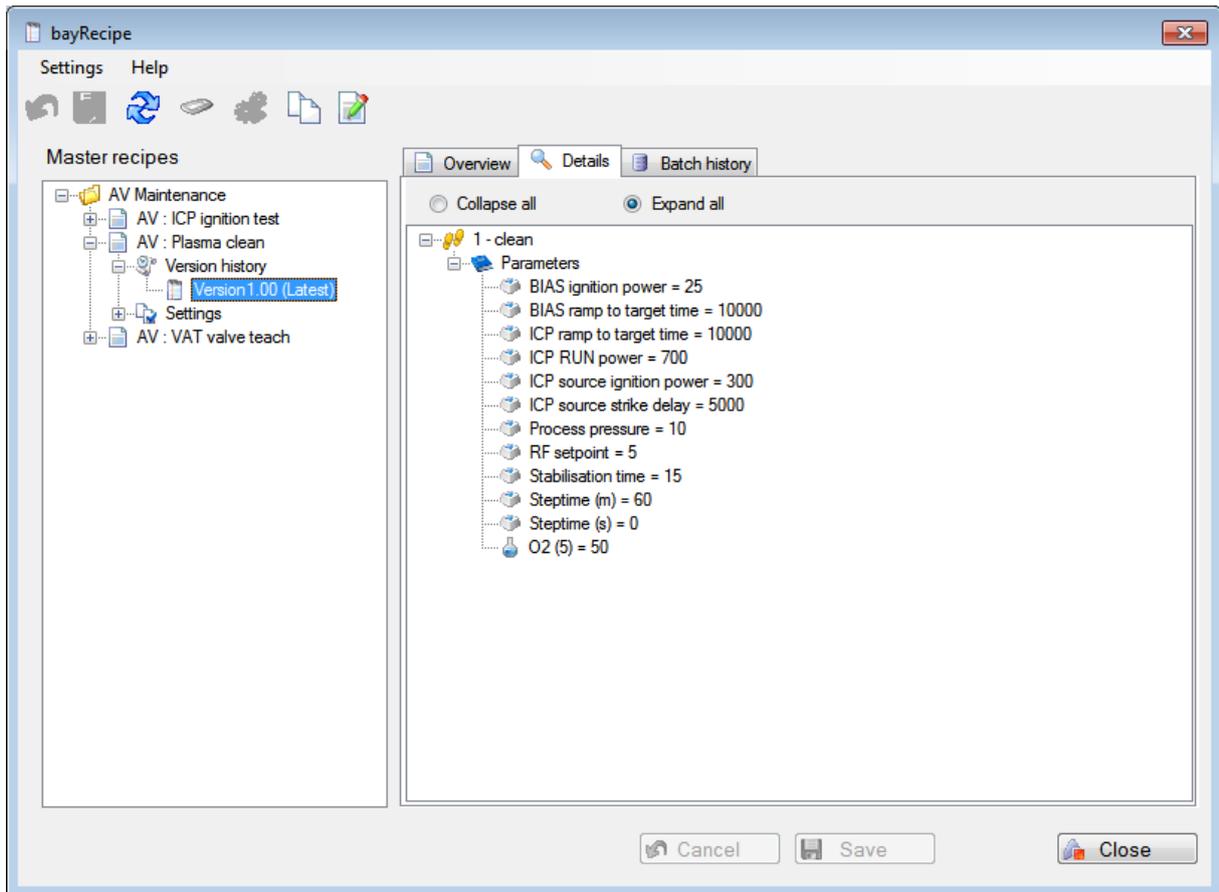
When a batch is started the Master recipe is copied to a Control recipe. In this version the operator cannot make any changes in the Control recipe and therefore it's an exact copy of the Master recipe.

### **Recipe list**

The list in left end of the form is showing all recipe categories with the related recipes. All operations that can be made on a node is reachable by a right-click.

Each recipe has a child node called Version history. It lists all versions of the recipe. By clicking a version the data for the recipe will be displayed in the tabs.

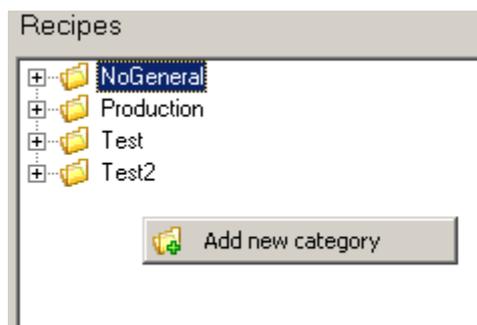
Under Settings it's possible to set if the recipe should be listed in the batch start form as well as whether or not the recipe should request a material ID input (if set to required, the system will demand a material ID for each run of that specific recipe).



Recipe editor – List of recipes

### Add/edit recipe category

A recipe must be placed in a category. The list in the left part is showing all recipe categories. To add a category just right-click in a free space in the recipe list and click Add new category:

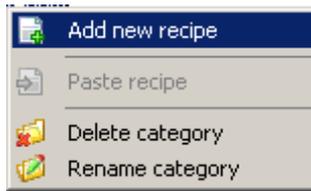


Recipe editor – add/edit category

After the category is named it's shown in the list. The category can be renamed and deleted (only if there are no recipes in it). Again just right-click on the category to get the actions available:

### Add recipe

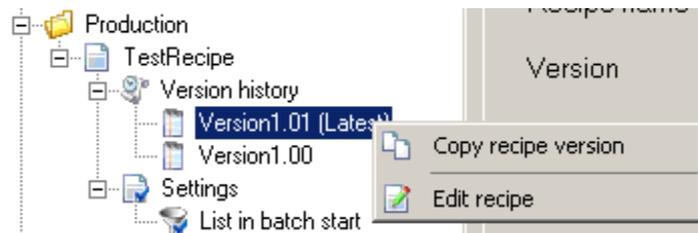
To add a new recipe right-click the category where the recipe should be saved and click Add new recipe. A new recipe will then be created. There are two tabs that has to be filled out for the recipe: Overview, Details. When a recipe is added or changed it's possible to click Cancel and all changes made will be lost.



Recipe editor – add recipe

### Edit recipe

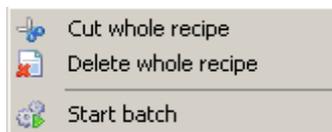
To edit a recipe right-click the latest version (it's only possible to change the latest version) and choose *Edit recipe*. If the latest version has been involved in batch activity a new version is created.



Recipe editor – edit recipe

### Cut recipe

A recipe can be moved from one category to another. By right-clicking the recipe name and selecting *Cut whole recipe* and then right-clicking a category the recipe can be moved.



Recipe editor – cut recipe

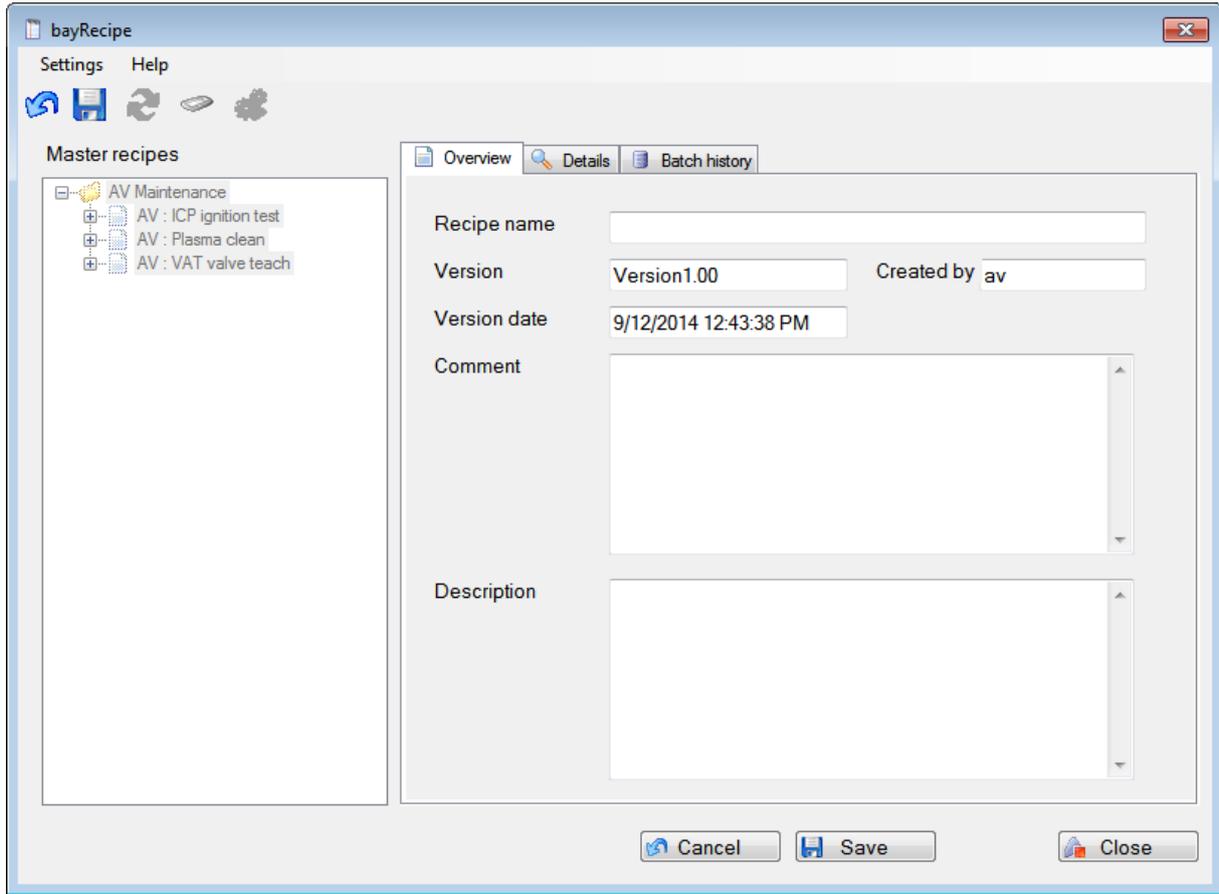
### Delete recipe

If the *Delete whole recipe* is selected the whole recipe will be deleted. A recipe that has been involved in batch activity can not be deleted.

### Copy and paste recipe version

A recipe version can be copied. Just right-click a version and choose *Copy recipe version*. To paste, right-click a category where the new recipe should be placed and choose *Paste recipe*. The new recipe will be a copy of the selected recipe version.

## Overview



Recipe editor – overview

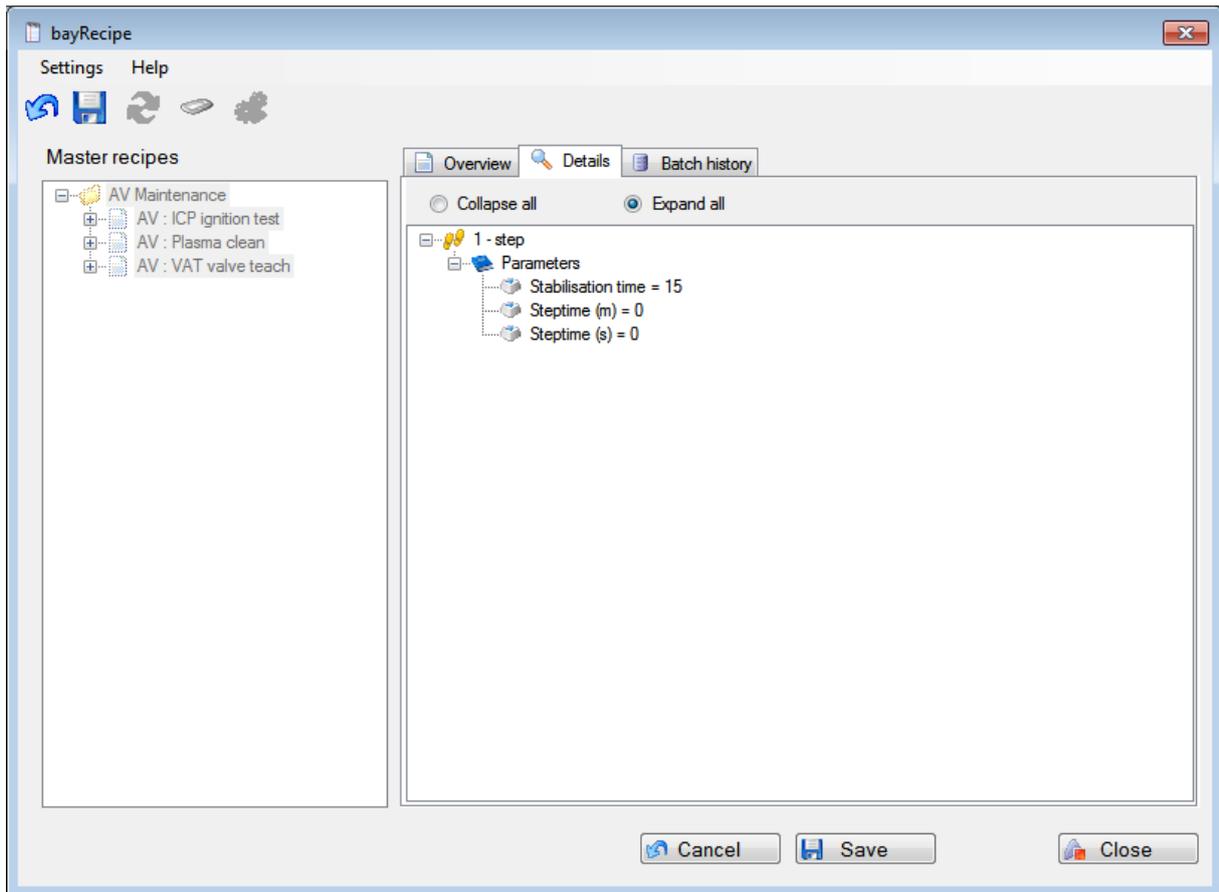
Field	Description	Editable
Recipe name	Name of recipe name must be unique.	Yes
Version	Version always starts with <i>Prefix</i> 1.00.	No
Created by	The user currently logged in to the system	No
Comment	Arbitrary text of maximum 250 characters.	Yes
Description	Arbitrary text of maximum 250 characters.	Yes

Recipe editor – field overview table

## Details

In the details tab the recipe step with the parameters are presented. A step consists of one or more parameters. The steps are evaluated according to the step number. The parameters are the set values that are going to be sent to the process. By default, each recipe step has 3 parameters. Stabilisation time<sup>1</sup>, Steptime (m) and Steptime (s). Steptime (m) and Steptime (s) is merely two fields used to define the process step time. For example, if the step should be 1 minute and 30 seconds long, Steptime (m) should read 1, and Steptime (s) should read 30.

<sup>1</sup> If stabilisation time is set to 0 in steps after the 1<sup>st</sup> step, and plasma power is called for, the plasma will stay on from one step to another. However, if Stabilisation time is set to anything else but 0, the plasma will always extinguish between steps.

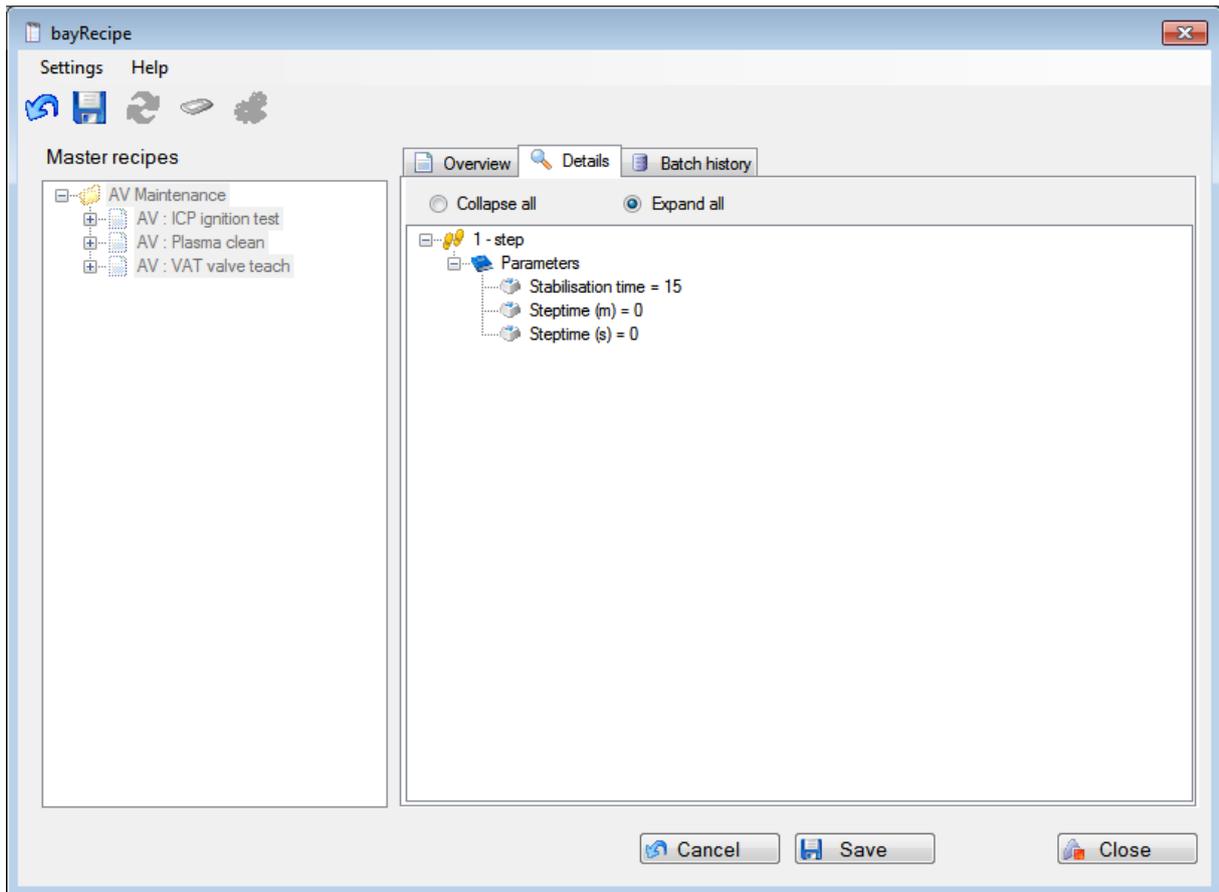


Recipe editor – details tab

## Steps

There are no limits of how many steps that can be created. By clicking a step the corresponding parameters are shown to the right.

To add a step, just right-click on a empty space in the right step window click "Add new step".



Recipe editor – add step

Then the following form will be shown:

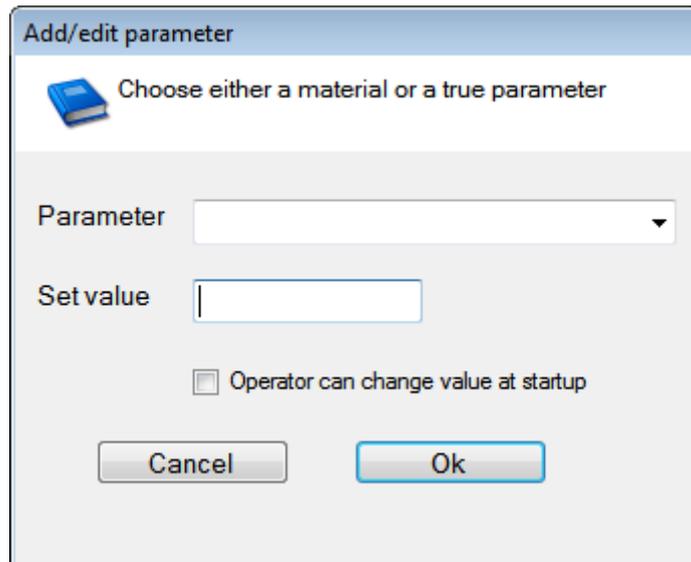
Recipe editor – add step dialog

Both the the step number and the name must be unique. After pressing Ok the new step will be compared with the General recipe which is a recipe that all new recipes are based on (this general recipe cannot be changed). If the general recipe have some default parameters they are automatically added. In this application the general recipe contains two default parameters: Stabilization time and Process time.

A step can be deleted and changed (right-click a step). If a step is deleted the corresponding parameters are also deleted.

### Parameters

To add a new parameter, first select a step the parameters is going to belong to. Right-click the parameter list and choose *Add parameter*. The dialog below will appear.



Recipe editor – add parameter

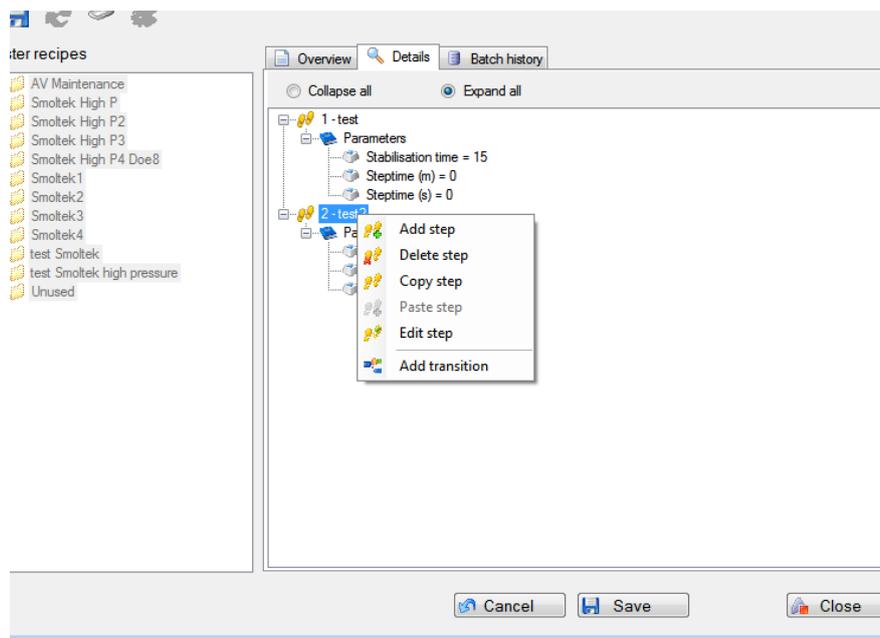
If the parameter is included in the General recipe the default value and the limits are given. The same parameter can only be used once per step.

Click Ok to save the parameter.

When both the Overview and Details tabs are filled click Save to save the changes to the database.

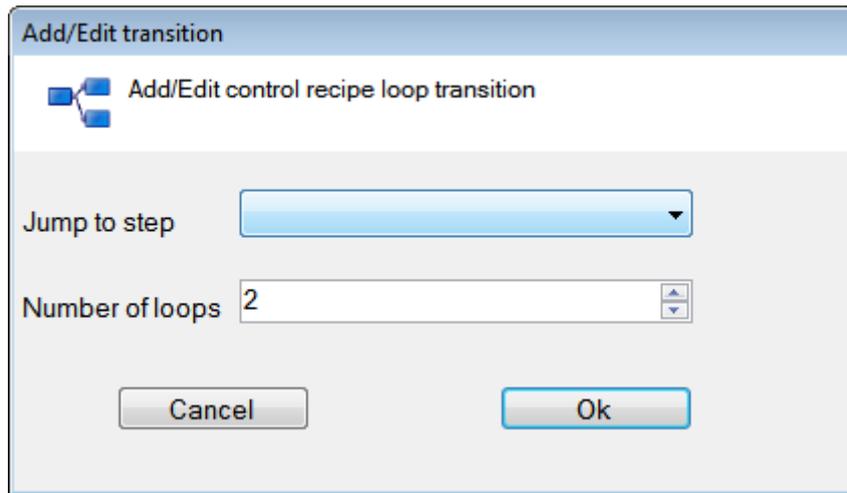
### Step looping

You can program steps to loop, and you can also create loops within loops. To add a loop, right click on the active step. A list of options will be available. Select "Add transition".



Recipe editor – add transition (loop)

The "add transition" dialog comes up.



Recipe editor – add transition dialog

In the "Jump to step" drop down, all available steps are shown. Select the step you wish to loop to, and adjust number of loops. The system will now jump from the step where the transition is added to the step assigned in the dialog, and the number of jumps

## Common process parameters

Listed below are a number of standard parameters commonly available.

Typical parameters	Unit	Description
Bias ignition power	W	If a specific ignition power is to be used, you can define it using ignition power. The functionality is such as that the system will ignite the plasma using this power, and once plasma has been ignited, it will revert back to Bias run power.
Bias ramp to target time	ms	Holds the time in milliseconds for the system to move from ignition power to run power.
Gas (1) – Gas (20)	sccm	Assigned process gases.
Cload position	%	Cload position for bias matching network (presets). The system will move the load capacitor of the matching network to this position before trying to ignite plasma.
Ctune position	%	Ctune position for bias matching network (presets). The system will move the tune capacitor of the matching network to this position before trying to ignite plasma.
DC bias setpoint	Vdc	If selected, the system will drive the RF power to the bias electrode to match the selected DC bias value. If a Bias run power is programmed at the in the same step, the RF power setting will take priority.
DriveMatch	Boolean (1/0)	This is a Boolean parameter, indicating the system to drive matching network presets to the programmed locations. If this is set to 1, the system will drive the networks. If set to 0 the load/tune presets will not be applied.
Endpoint recipe	Recipe name	This parameter will yield a list of available endpoint recipes.
Flush	Boolean (1/0)	This is a Boolean parameter, telling the system to operate the flush valves in the gas panel. If set to 1 the flush valves will activate per pre-defined times/cycles. If set to 0 flush will be ignored.
He backside cooling flow	sccm	He backside cooling flow setpoint.
He backside cooling pressure	Torr	He backside cooling pressure.
ICP Cload position	%	Cload position for ICP matching network (presets). The system will move the load capacitor of the matching network to this position before trying to ignite plasma.
ICP Ctune position	%	Ctune position for bias matching network (presets). The system will move the tune capacitor of the matching network to this position before trying to ignite plasma.
ICP ramp to target time	ms	Holds the time in milliseconds for the system to move from ignition power to run power.
ICP RUN power	W	Holds the RF power to use when running the ICP source (if no ignition power is selected, this will also be the ignition power)

Typical parameters	Unit	Description
ICP source ignition power	W	If a specific ignition power is to be used, you can define it using ignition power. The functionality is such as that the system will ignite the plasma using this power, and once plasma has been ignited, it will revert back to ICP run power.
ICP source strike delay	ms	A delay in milliseconds from when the bias supply has ignited plasma, and when the ICP RF power comes on (if a ICP source ignition power setpoint exists, this will be used, and then if a ICP ramp to target time exists, the system will ramp to run power during that time).
Required basepressure	Torr	If used, the system will need to reach this pressure before a plasma process will start.
Start pressure	mTorr	If a process has difficulties igniting at the desired run pressure, an ignition pressure can be programmed. This pressure will be maintained until a plasma is detected, then the system will automatically throttle the conductance to achieve the Process pressure setpoint.
End pressure	mTorr	Target pressure if using a "Start pressure" parameter.
Process pressure	mTorr	Process pressure.
Over etch time	s	The over etch time dictates how long the process should continue after endpoint is detected.
Over etch percentage	%	The over etch percentage dictates how much over etch the system should do after endpoint is detected. If the Over etch percentage is set to 10%, and the system reaches endpoint after 60 seconds, the etch will continue for an additional 6 seconds. This is calculated automatically when the system triggers endpoint.
Process time (m)	m	Holds the process step time minute section.
Process time (s)	s	Holds the process step time second section.
Process development mode	Boolean (1/0)	If set to 1, the system will run the process in process development mode. This allows for real time adjustments of all process parameters.
Purge	Boolean (1/0)	If set to 1, the system will execute a purge step (flushes the gas delivery manifold)
Pump down	Boolean (1/0)	If set to 1, the system will execute a standard pump down step.

Contact Paul Horng (x4827, [horng@udel.edu](mailto:horng@udel.edu)) for assistance