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Software Manual Cardinal Fill Tool

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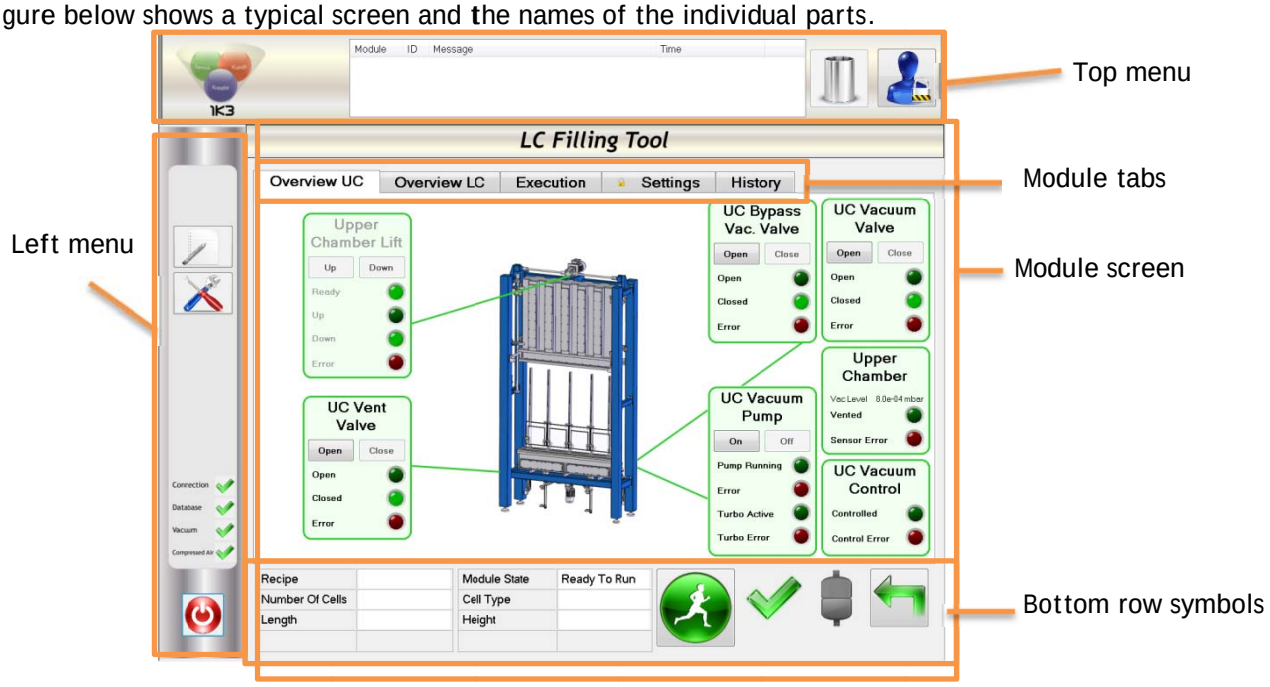
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1 Introduction

This is the manual of the control software for a filling tool that is intended for the production of so-called 'Smart Glass': a switchable glass type based on LCD material. The software covers the filling tool, which is used to fill a batch of cells with LCD material. The input control of the software is a 19" monitor with touch screen that is mounted to the right of the filling too. It can be equipped for with a separate keyboard for input.
The equipment is Soft-PLC controlled, and the IO is redirected to the HMI software. The PLC software should be running before attempting to start the HMI. The PLC software is automatically started when the PC is started.
The software set-up was based on the line set-up at Merck Window Technologies and this was used to control a number of modules. Some aspects of the software still reflect this set-up. Also some buttons or items might not reflect the exact screen layout of the tool, but this is mentioned in the text near the image

2 General software set-up and meaning of the symbols

Any screen in the software is divided in a number of sections. These sections and the symbols that are used are explained below. Some parts of the screen are always visible like the top and left menu, and other parts are present in every module, like the bottom symbol row. The figure below shows a typical screen and the names of the individual parts.



2.1 Top menu

The top menu is explained below:



Error / Warning Message log: Every time an error or warning occurs the message of the warning or error is displayed here. Using the clear message log button the log can be cleared so new messages are immediately visible. The color of the message indicates if the message is fatal or not:

- **Orange:** non-fatal message (warning). The module can still run even with this message.
- **Red:** fatal message (error). The module falls into failed state.

The meaning of the heading:

- **Module:** This is the name of the module which has generated the message, i.e. LC Filling or System.
- **ID:** The ID number of the error or warning message.
- **Message:** a short description of the error message.
- **Time:** The time at which the message occurred.

Please see the individual module description for the meaning of an individual error-message.

Clear message log: This button clears the warning / error message log. This is useful to see immediately if a new message has occurred. In case the button is pressed inadvertently, the module in error state can still be recognized in the main overview screen and the error can still be addressed in the individual module history log. The symbols have the following meaning:

	There are messages in the message log that can be deleted
	There are no messages in the message log (pressing the button will not have any effect)

 Pressing the clear message log doesn't resolve the error.

User Login button: Different user levels have different access to the settings, recipes, and buttons in the individual modules and the recipe editor. With this button the user level can be changed. When the button is pressed in operator mode, a login screen appears and in this screen a correct password needs to be entered to change the user level. If the user level is higher than operator level, pressing this button results in a logout and change to operator

level. The next user levels are available and their symbols are shown in the table below. Included are the passwords of each level when the equipment was delivered:

	Operator: For operator level no login is needed. This is the lowest user level. In case of a certain time of inaction (no input) the user level is automatically changed to operator. The operator is the most limited user.
	Process engineer: The initial password of the process engineer is PENG. The process engineer can among others change recipes and change the recipe that is carried out by the process in a module.
	Engineer: The initial password of the engineer is ENGI. In addition to what the process engineer can do, the engineer can among others also change settings.
	Supervisor: The initial password of the supervisor is SUPER. The supervisor is the highest authority on the tool and can also change the passwords of process engineer and engineer. Among others, the supervisor has access to deleted recipes.

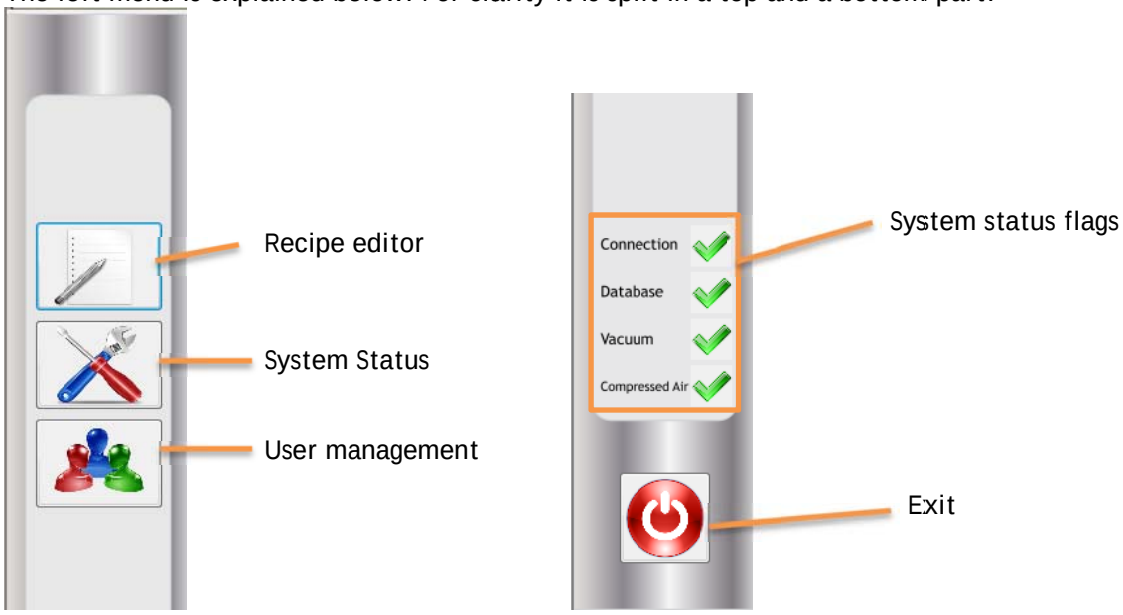
For details on the access rights of the individual user levels see the individual module description.

	Passwords are not case sensitive

	It is the responsibility of the customer/supervisor to prevent unauthorized use of the equipment. One cause is that higher level passwords are public knowledge. Please change passwords from the setup value and keep passwords secret and only known to authorized levels.

2.2 Left Menu

The left menu is explained below. For clarity it is split in a top and a bottom part:



	**Recipe Editor:** clicking this button opens the recipe editor. The minimum level to access the recipe editor is Process Engineer.
	**System Status:** clicking this button opens the System Status form.
	**User Level Management:** This button is only accessible on Supervisor level. It opens a form to change the passwords of the supervisor, engineer and process engineer. It also automatically opens an on screen keyboard.
	**On Screen Keyboard:** The OSK can be accessed by ticking on the left of the screen or on the textbox that is in need of input
	**Exit:** Pressing this button will exit the program. It will generate a pop-up screen to ask for confirmation.

Meaning of the System Status flag symbols:

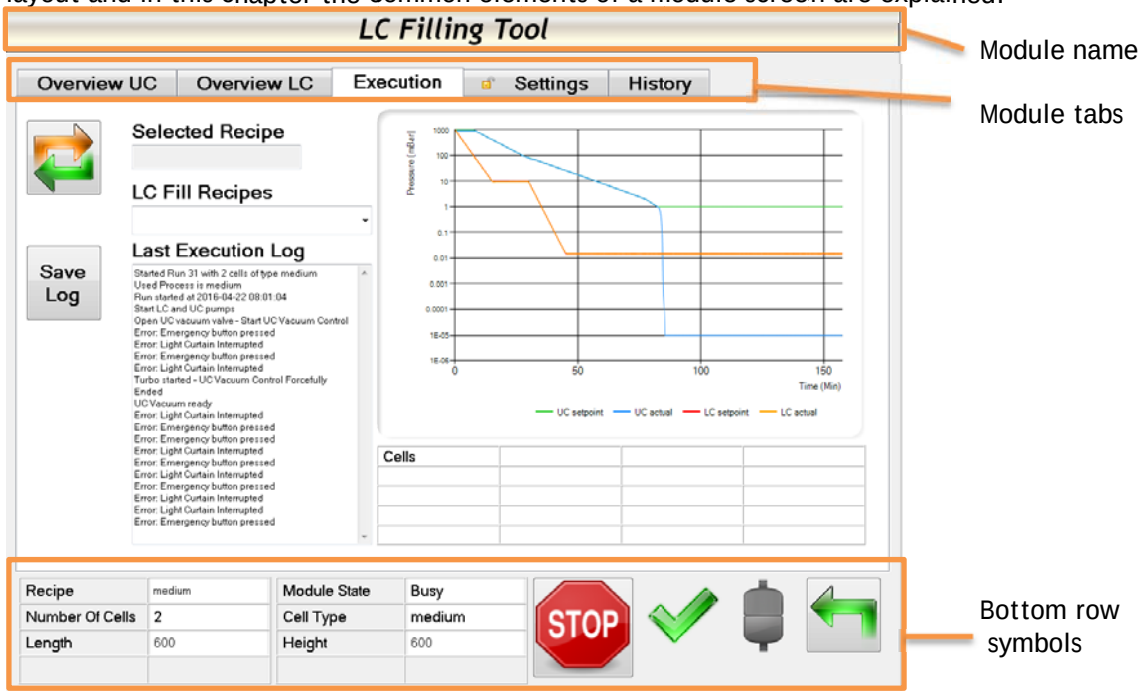
	The service or mains is not available or not valid
	The service or mains is available and valid

Meaning of the individual System status elements

Database	This shows that the HMI software can access the local database. The database contains information about recipes, history, events and cells.
Vacuum	This shows that the vacuum mains is available for the cluster tool. Because compressed air is used to create vacuum the status is equal to the compressed air status. In case of the Cardinal tool there is no vacuum made by compressed air, and this flag is standard put on green
Compressed Air	This shows that the sufficient compressed air mains is available for the tool. However, as no compressed air detection is available, this flag is automatically set to green.

2.3 Module Screen.

The equipment consists of 1 module and for each module a screen is present. Next to the module screen there is a recipe editor, and a system setting screen. Each module screen has the same layout and in this chapter the common elements of a module screen are explained.



Module name: This is the description of the module.
Module Tabs: The module contains a number of tab pages with information and control. The next tab pages are always present: Overview, Execution, Settings, and History. Additional tabs can be present and some modules may not have settings available but still have the tab present. A symbol in the tab indicates if the tab can be accessed or is locked.

No symbol	Tab page can always be accessed at any user level
	Tab page is locked in this user level, tab page can't be accessed
	Tab page is unlocked in this user level, tab page can be accessed

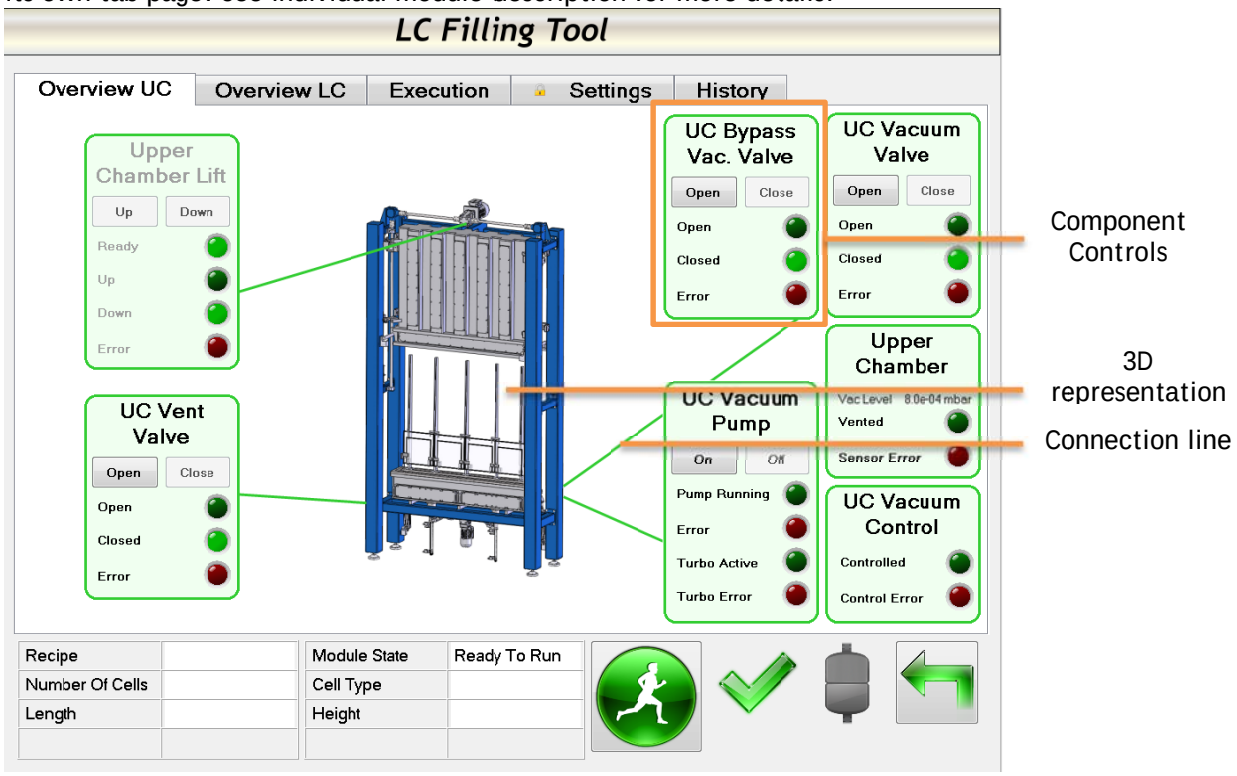
Bottom row symbols: In the bottom row you can find several symbols and also two tables. The symbols are present in every module while the content of the table can vary from module to module, although some items are always present, like the module state and the selected program.

2.3.1 Tab page explanation.

The individual tab pages are explained below:

2.3.1.1 Overview:

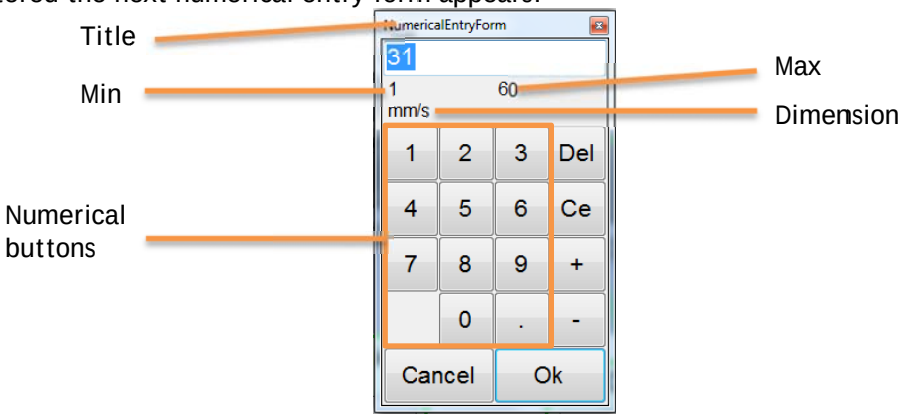
The overview tab contains the controls and status of the individual components of the module. Here you find for instance the motor control, control of the air table, etc. When the automatic process is running these controls are faded and can't be accessed to prevent disturbing the automatic process that is running in the module. The overview tab can contain a 3D image of the tool with lines connecting the individual components, like the sample below. There can be more than one overview tab, for example when the module contains too many components to fit on a single screen. Sometimes a component is so complex that is has its own tab page. See individual module description for more details.



A component control of a module is represented by a green rounded box. The general rules for the contents of this box are explained in the table below:

Start	Active button. This button can be pressed to change the state of the component. It can become inactive when the state of the component changes.
Stop	Inactive button. This button cannot be pressed at the moment. It can become active when the state of the component changes.
	Green LED on. The state mentioned in the label is active. For example the axis is calibrated.
	Green LED off. The state mentioned in the label is inactive. For example the vacuum is not detected.
	Orange LED on. The component is busy going to a new state, but not yet ready, i.e. a valve of the air conveyor is opening. In case the LED represents the calibrated state of an axis it means that the axis has run on the home sensor. Please see the component description if this LED occurs or not.
	Red LED on. The error state mentioned in the label is active. In some instances also the component borders starts to flash red-green.
	Red LED off. The error state mentioned in the label is not active.

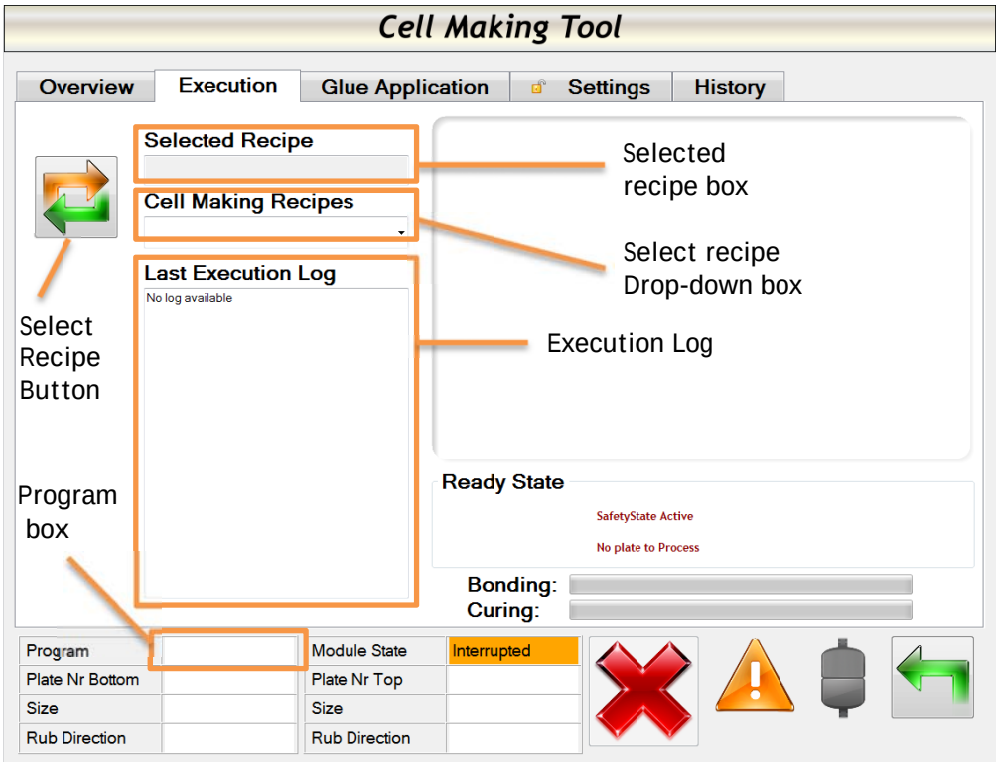
When a button is pressed, it is possible that the tool will require a numerical entry, for instance to enter a new axis position or axis speed. In case the component needs a value to be entered the next numerical entry form appears:



Title: The title shows the description of the value that needs to be entered.
Min: Lower bound of the value to be entered.
Max: Upper bound of the value to be entered.
Dimension: If applicable, the unit of the value to be entered.
Numerical buttons: Press to enter a numerical value.
Del: Delete last entered symbol.
Ce: Clear entered data.
Cancel: Cancels the data entered and also the component action.
Ok: Accepts the entered data in case this is within the lower and upper bound. In case the entered value is not within the lower and upper bound, the entered data is shown red and is changed to the upper or lower bound.

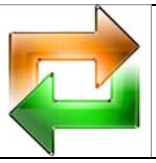
2.3.1.2 Execution

The Execution tab contains information that is updated during execution like graphs and the execution log. What graph is shown depends on individual module. Its common elements are shown below. It is also the tab page in which the program connected to a plate or cell can be changed.



Execution Log: When the automatic program is running on the module, it will generate messages to report its current progress to the user. These messages are shown here. It will also clear the log when a program is started and show an error when it occurs during automatic but also during manual operation.

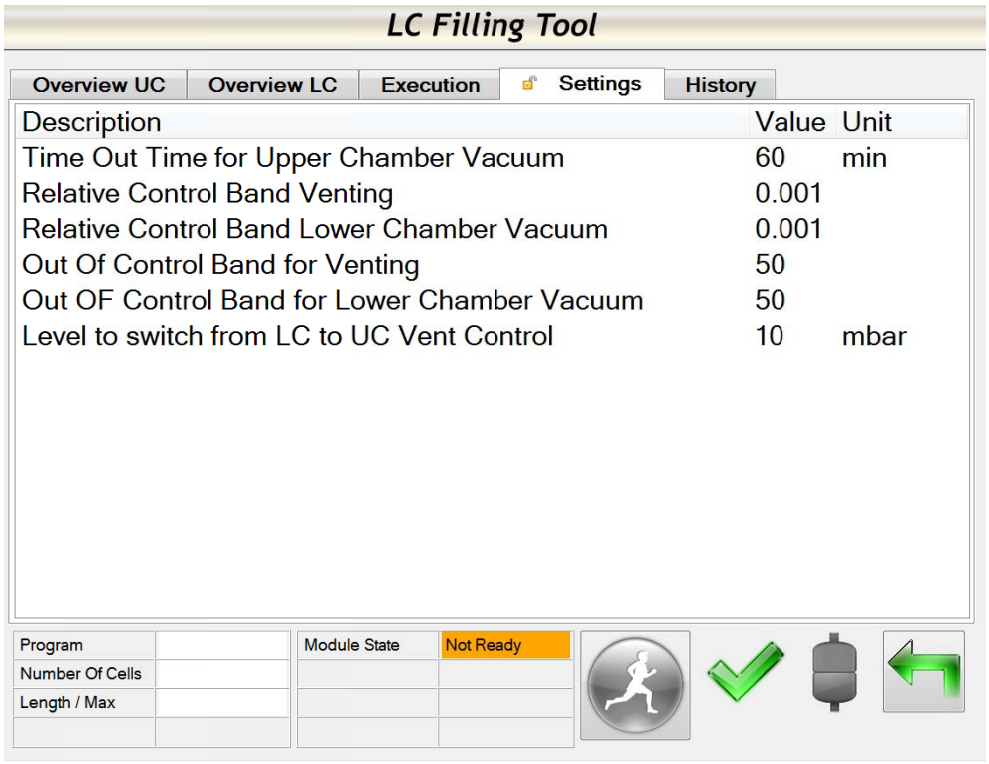
Select Recipe button, Selected Recipe box, and **Select Recipe drop-down box**: These controls enable the change of the default program that was selected during the start of the run. After aborting the run it is possible to change the recipe by using these buttons.



To change the recipe, select a recipe in the select recipe drop-down menu and press the select recipe button. The Selected Recipe box will show the new recipe. It will also be visible in the bottom row Program box.

2.3.1.3 Settings

The settings tab contains the settings of the module. Settings are calibration or other parameters that need to be set once and can be changed from here. The required user level for accessing and changing settings is Engineer level or higher. To change a setting, click or tab the setting you would like to change. A numerical entry form appears (see overview tab) and in this form you can enter a new value for the settings. The meaning of the Settings are explained in the individual module description.



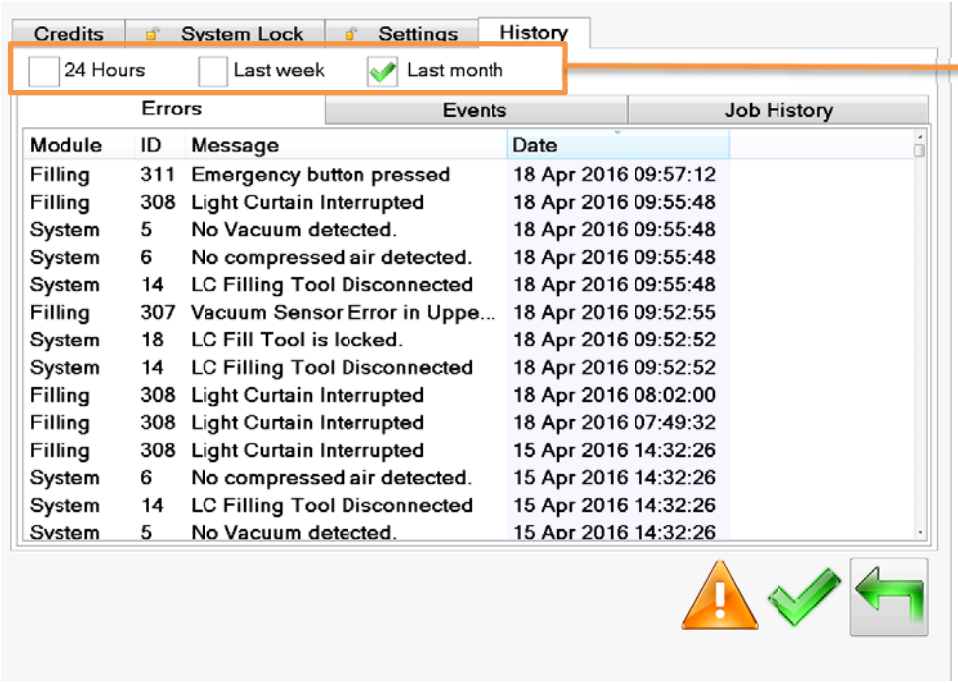
The meaning of the individual columns:

Description:	This contains a description of the settings.
Value:	Present value of the settings.
Unit:	If applicable, the unit of the settings.

Settings can have a large impact on the functioning of a module. Changing settings is hardly ever required. Do not change settings lightly, as this can lead to malfunctioning of the tool.

2.3.1.4 History.

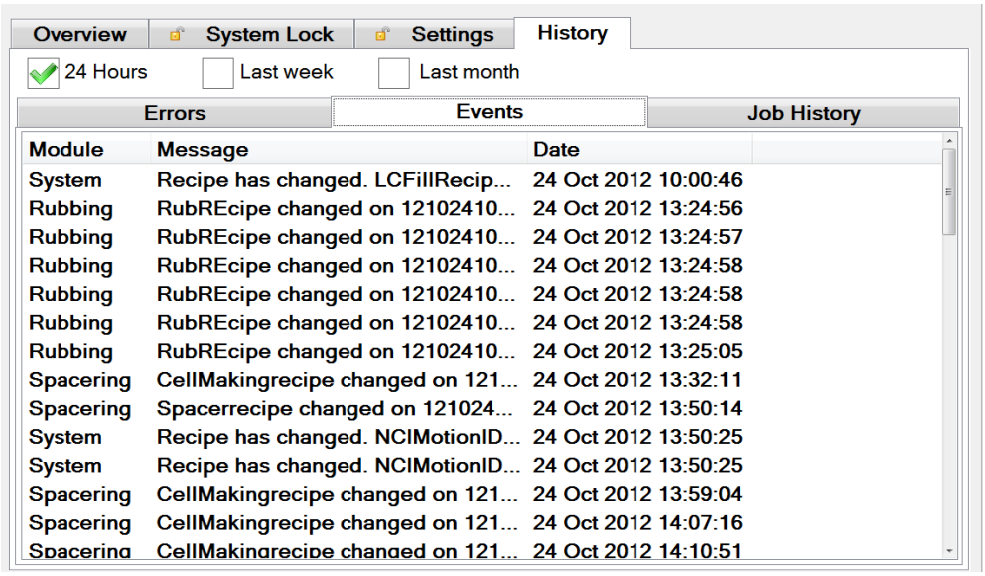
The history tab contains the history of the control. This history is split up in events and errors. If an error in the message log is erased, it can still be retrieved in the module history. Next to the 6 modules, the system screen also has a history control which logs the changes in recipes and events that occur in the system.



Period Selection boxes: By clicking one of these boxes, the period can be selected from which errors and events are shown. Available is last 24 hours, last week (7*24 hours) and last month (up to one month back). All this data is taken from of the database.

Tab Page Errors: The columns have the next meaning:

Module:	The name of the module that generated the error.
ID:	Error ID number
Message:	The error description that matches the error ID.
Date:	Date and time at which the error has occurred.

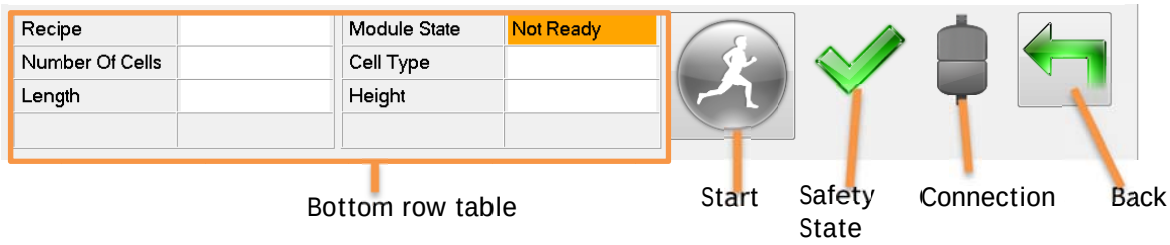


Tab Page Events: The columns have the next meaning:

Module:	The name of the module in which the event was generated.
Message:	The description of the event.
Date:	Date and time at which the event has occurred.

2.3.2 1.3.2 Bottom row symbols

The bottom row contains several symbols and two tables. The contents of the tables may vary from module to module but some parts of the table are always present. See an example of the bottom row below:

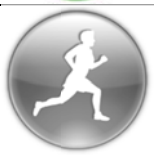


The start and back are buttons, the Safety State and Connection state are symbols indicating a state of the system. The symbols change depending on the state of the tool. The visualization of the Start button symbol depends on the module state and is also explained here.

	**Back:** This button will either return to the operator screen or will switch between module screen and operator screen.
	**Connection:** Module is connected to the control software. All controls will have meaning and will operate the module.
	**No Connection:** Module is disconnected. In case the PLC software is not running or the HMI failed to connect to the PLC. The module does not function and commands from the software do not operate the module. The state of the module is reflected in the **Module State.**
	**Safety state:** Safety state is inactive. Controls will respond normally.
	**Safety state:** Safety state is active. This means that for reasons of safety that controls are overruled by the software. Safety state should be inactive to run automatic programs.

The Start button should be used to start an automatic program in the module. The symbol on the start button reflects if this is possible and if not why. Sometimes an operator action is needed to continue the program. In that case the symbol of the start button reflects this situation. The symbol takes into account the user level that is operating the machine. So it is very well possible that for a certain user level the tool is ready and at another (mostly lower)

user level the tool is not ready. For the requirements for the module to be ready for use, please check the individual module description.
The start button is also dual use: When the automatic process is running, pressing this button will abort the current process and put the module in aborted state.

	**Start:** Module is ready to run the automatic process. Pressing the button starts the automatic process and will set the module state to busy.
	**Start:** Module is not ready to run and the automatic process can't start. Pressing the button will have no effect. In the execution tab and in this manual one can find the requirements for setting the module to a ready state.
	**Start:** Module is executing the automatic process. Pressing the button will abort the running process and will set the module to an aborted state.
	**Start:** Module is in a failed state. Pressing the button will have no effect. Main difference with the not ready state is that component(s) in the module are in a failed state.

2.3.2.1 *Bottom Row Table*

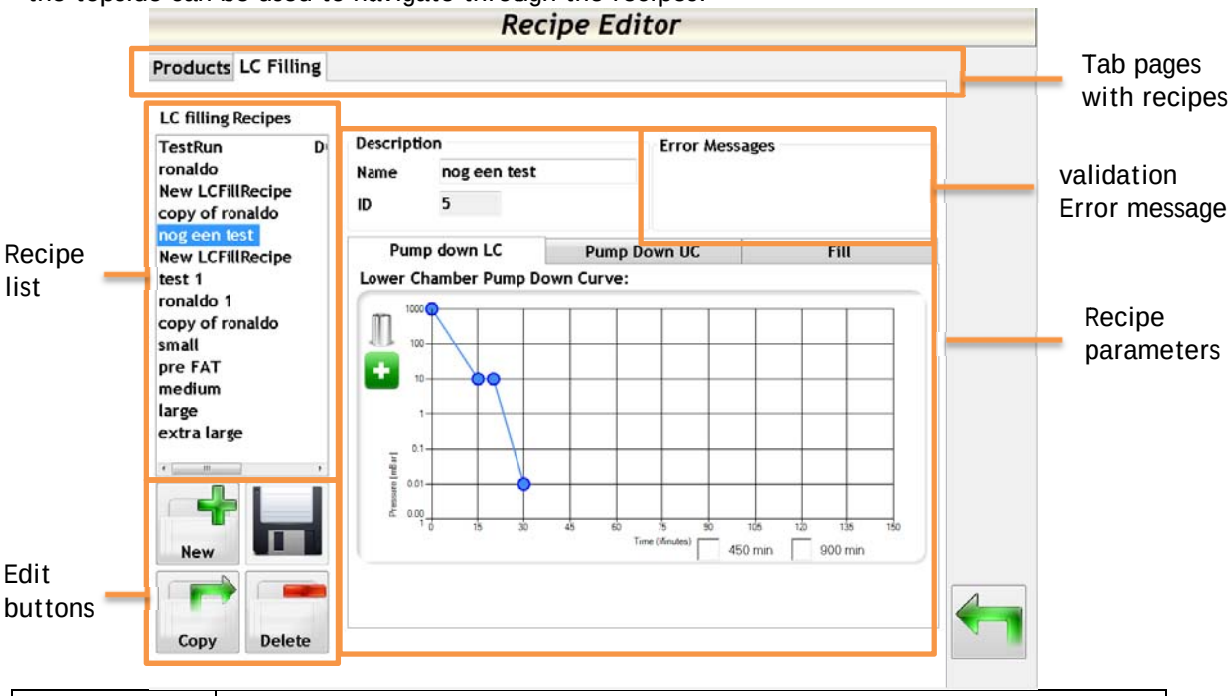
The bottom row table differs from module to module. However, two important items are always present:
Recipe: This shows the present loaded recipe. In case this is empty, no recipe is loaded in the module.
Module State: This reflects the current state of the module. Its meaning is explained below. The colors reflect the colors shown in the module screen when this module state occurs.

Module State:	Description
Done	The module has finished the automatic process and the products present are now ready to move to the next process step. Difference with a ready-to-run state is that now finished products are present in the module.
Ready to Run	The module is ready to run the automatic process. Products in the module have not yet finished processing.
Not Ready to Run	The module is not-ready-to-run but also not in a failed state.
Busy	The module is executing the automatic process.
Aborting	The module is aborting (stopping) the process. The abortion process is not yet complete.
Aborted	The module has completed aborting the process. The products inside the module have all been aborted also. Difference with ready-to-run/and not-ready-to-run state is that aborted products are present in the module.
Disconnected	The module is in a specific failed state: the control software detects that the module is not connected. See also connect symbol.

Failed	The module is in a failed state. One or more individual components have experienced an error.
Interrupted	The module is in a interrupted state. This is caused for instance when a (safety) door is opened, or the lightscreen is interrupted impeding the movement of motors.

2.4 General Recipe Editor Screen

The recipe editor screen is standardized and will always show the same components. A typical screen is shown below. It shows the product recipes. This tab page is just an example, but every tab page shows a (part of) a recipe and works in the same way. The tab page control on the topside can be used to navigate through the recipes.

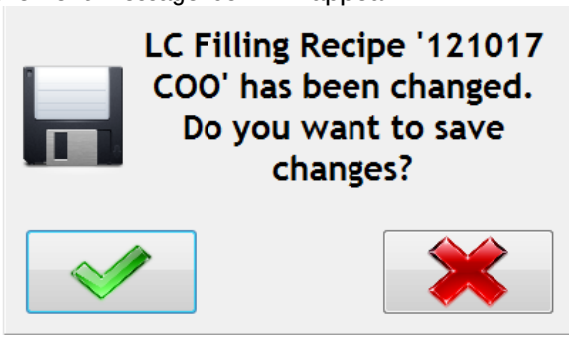


Tab pages:	Each tab page is a (part of a) recipe, and show the parameters for the process in a module. The explanation of the parameters is described in the chapter concerning the module. Next to recipe tab pages, there is a tab page for the products.
Recipe list:	This shows the available recipes that are present in the database. From this list a recipe can be selected, and then the recipe parameters are shown. If no recipe is selected the complete recipe parameters field is empty. In case the recipe list is so long that it doesn't fit the window, a scrollbar is added at the bottom.
Recipe parameters:	This screen is different for each tab page, and shows the recipe parameters. For explanation of the parameters, see the module description. The **Name** and **ID** fields are always present. These show the name of the recipe (as shown in the recipe list) and the ID in the database. This value can't be edited. When no recipe is selected, the recipe parameters will be empty.
Validation Error Messages:	In case an invalid parameter value is entered and a save is attempted the fault will be marked with a red triangle. A warning icon and an explanation will be shown in the Error messages box.

Edit buttons

	**New:** Adds a new recipe to the list. This new recipe will be named **New Recipe**. After selecting it, it can be edited and saved under a new name.
	**Copy:** Creates a copy of the selected recipe. The name will be **Copy Of** followed by the old name. Then select it to edit it. This function is intended to minimize input when only a few parameters need to be altered.
	**Save:** Pressing this button will attempt to save a recipe. If a recipe is selected the button will be inactive until changes are made. When pressed it will validate the recipe and save it to the database. In case the entered data is faulty or not within process limits the data is not saved and a **validation error** mark is set.
	**Delete:** Pressing this button will remove the recipe out of the list. It is now no longer available for User levels below Supervisor. It is not physically deleted from the database.
	**Validation error:** If the data that is entered is not valid and a save is attempted, this flag will be visible next to the entry that is not valid. If the mouse cursor is placed on top of the icon, it will show a line of text indicating why the input is faulty. This message is also displayed in a special Error Messages box that is placed on the recipe screen

Before the recipe is stored in the database, the entered data is validated, and if the data is invalid the recipe will not be saved. When a recipe has been edited and one attempts to select another recipe, the next message box will appear:



If the Cancel button is pressed, changes are discarded, if the Accept button is selected, the recipe editor will validate the entered data and in case of valid data save the recipe. A successful save will also be indicated by a message box, like the one below. The message box will be visible until the accept button is pressed.



The tab pages all do belong to a module, like the one shown in the table below.

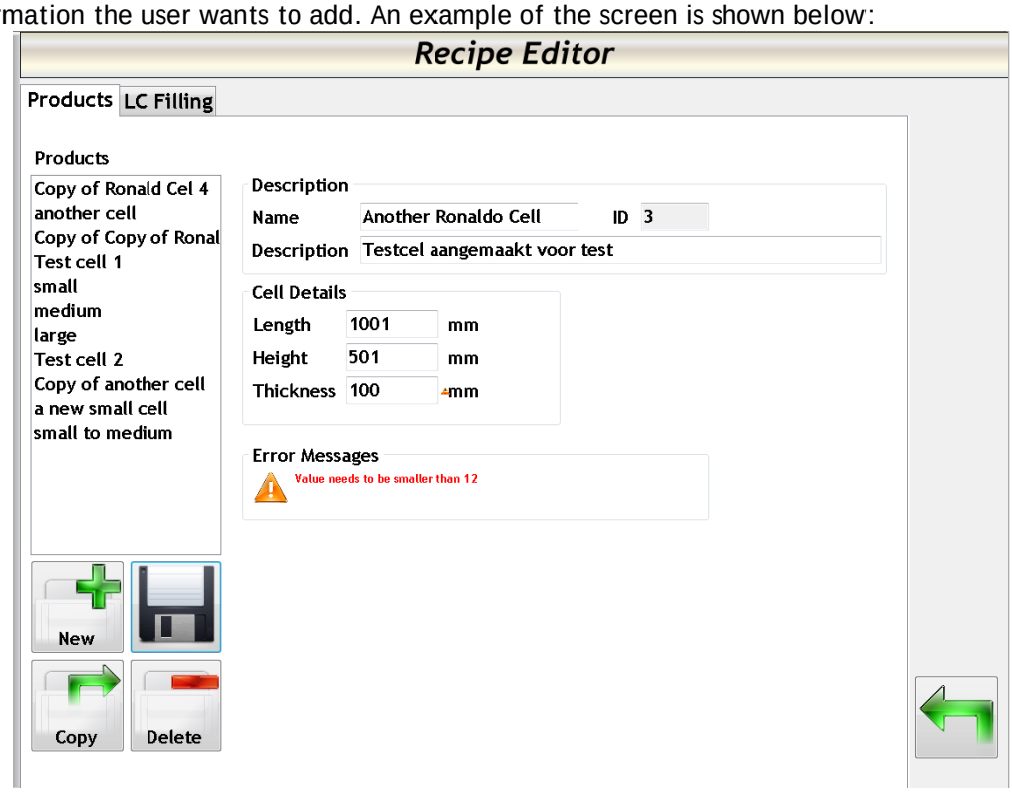
Module	Recipe pages
LC filling	LC Filling, Products

2.5 User access rights

Item		P	E	S
Edit recipe parameters		✓	✓	✓
Save and delete recipes		✓	✓	✓
See and edit deleted recipes				✓

2.6 Products

The products recipe tab is the only tab that is not connected to an individual module, but to the products process. It generates a list of parameters that are typical for a certain product type. It also has room in a description to indicate a specific tests, customers or whatever information the user wants to add. An example of the screen is shown below:



The recipe editor for products has five fields. The meaning of the fields is as follows:

Item	meaning	Lower bound	Upper Bound
Name	Name of the product	> 3 characters	< 30 characters
ID	ID number in the database	-	-
Description	Description of the product, with far more room than the name	-	< 200 characters
Length	Length of the cell	300 mm	1500 mm
Width	Width of the cell	300 mm	1200 mm, <length
Thickness	Thickness of the cell	4 mm	12 mm

3 System Status

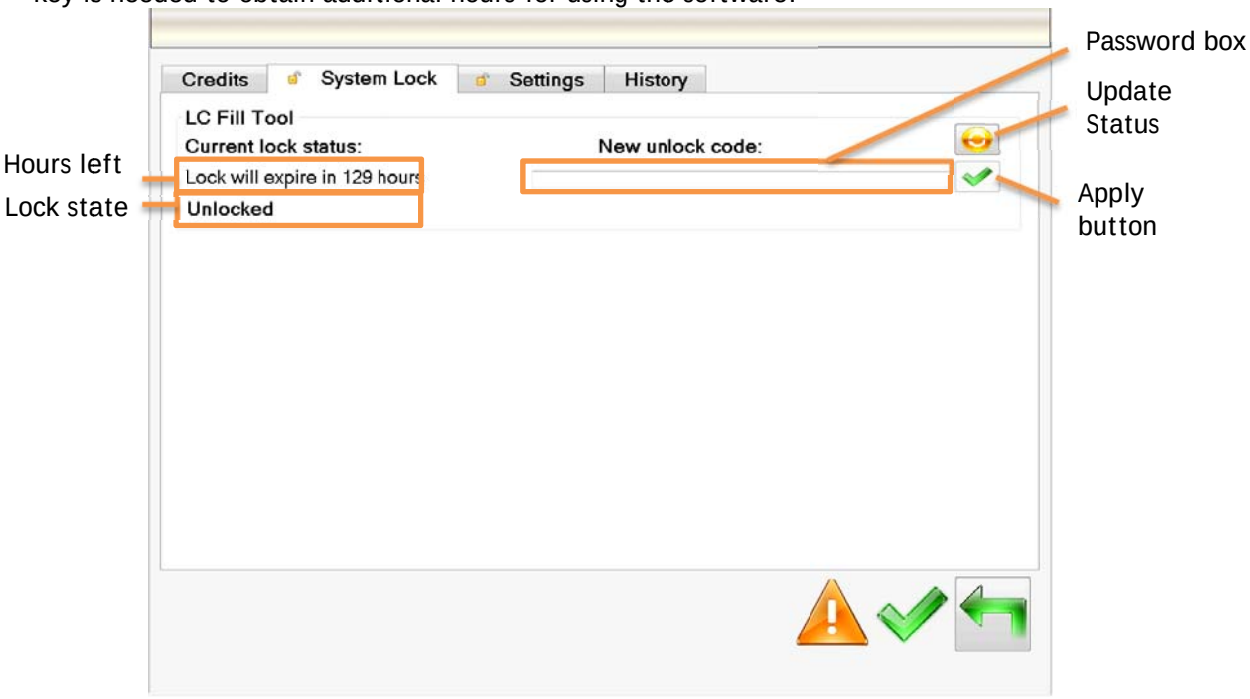
The system status screen is available for description of the items that concern all the modules and is not specifically connected to a single module. It has a structure comparable with a module structure. It doesn't contain an execution tab, but has a system lock Tab page.

3.1 Credits

The Credits screen shows the parties that were involved in creation and delivery of the system. It also shows contact info and any credits to external LGPL-parts of the software.

3.2 System Lock

The system lock screen shows the current status of the software lock. In case the software is completely released the system will be in a unlocked status. In all other cases a new software key is needed to obtain additional hours for using the software.



Hours Left:	This shows how many hours are left before the system will be locked. A warning will be given if this is less than 24 hours and an error will be given when the system is locked.
Lock State:	Shows whether the system is locked. In case of **"Locked"** the system is locked, in case of "**Unlocked"**, the system is unlocked and usable.
Password box:	In this box a new password can be entered. The password is 64 characters in length. If the password is valid, the Apply button will be enabled, otherwise it will stay in its disabled state.
Apply button:	If the entered password is correct, the apply button can be pressed and the new password is stored in the system.
Update Status button:	With this button the latest state of the lock status is reloaded.



A running process will not finish correctly when the hours left expire during running. Please do not start a new process when this cannot be finished in the remaining hour allowance.



Tampering, avoiding, removing, or in any way trying to defeat the software locking mechanism will be considered as ill use of the equipment and will void any warranty.

3.3 Settings Description

ID	Description	Default value	Unit	Explanation
1	Idle time before return to operator mode	10	Min	Time of inaction before returning to operator mode when logged in in a higher level.

3.4 User Level access rights

Item				
Access to System lock screen				✓
Enter Passwords to unlock system				✓

3.5 Error / Warning description

ID	E/W	Description	Remedy
1	E	**TwinCAT system not running:** The PLC control software has an error.	Check the TwinCAT logo in the bottom of the screen. If this is NOT green then the software is not running. Restart the computer and check again. If this doesn't resolve the situation contact service. If this is green, run debug viewer, contact service and supply the debug log.
2	E	**Could not establish a connection to the database:** The HMI software tried to connect to the local database and failed to get a valid connection. Database integrity could be lost.	Contact service.
3	E	**There was an error in a database Query:** A command to read or write to the database returned an error.	UNUSED. A log is maintained on database issues. This error will not pop-up.
4	E	**TwinCAT PLC not running:** The PLC control software is not running.	Check the TwinCAT logo in the bottom of the screen. If this is NOT green then the software is not running. Restart the computer and check again. If this doesn't resolve the situation contact service. If this is green, quit and rerun the application. If the problem remains, run debug viewer, start the application and contact service and supply the debug log.
5	E	**No vacuum detected:** No external vacuum is available for the LCFill tool.	UNUSED: No external vacuum is used for LC filling tool

6	E	**No compressed air detected:** No CDA is available for the LC Fill tool.	UNUSED: CDA is used in the LC Fill tool, but there is no detection for its availability.
9	W	**Invalid key entered:** The key entered was not a valid one. (Note: this message might not pop-up).	Obtain a legal code, check for typo's.
14	W	**LC Filling tool disconnected:** The LC Filling tool is not available for the HMI and is in disconnected state.	Rerun application. If persists check the Twincat icon if this is green. If not green, please start twincat and rerun application. If status persists contact service
17	W	**LC Fill tool will lock in X hours:** There is still X hours left of the hours allowance, before the LC Fill tool is locked.	Prepare to contact service for a new code. Note: if the tool is unlocked go to the system lock screen and press the refresh button.
18	E	**LC Fill tool is locked:** The hours allowance of the LC Fill tool has expired. The LC Fill tool cannot be used.	Contact service for a new code. Note: if the tool should be completely unlocked, go to the system lock screen and press the refresh button. If persists contact service

3.6 Tool is ready requirements

Ready state requirements not applicable

3.7 Safety State

Safety State requirements is not applicable. The safety state Icon will be in the On state when one or more connections are broken. Only when the ring is closed the green check will appear.

3.8 Interrupted State requirements

No interrupted state exist for this module.

3.9 Bottom row table description

This module has no bottom row table.

4 LC Filling Module

After the cell has been assembled, it is filled with LCD material. This process is carried out in a vacuum vessel. After evacuating the cells, filling is carried out by bringing the ports in the seal in contact with a bath of LCD material (mounted in a tray). The LCD material will flow inside the cell by capillary pressure, and when this is depleted by increasing the pressure on the LCD material bath. The filling speed should be as constant as possible during the filling process. When the vessel is fully vented, the process is completed and the cells are ready to be sealed.

The filling process is a batch process. The vacuum vessel consists of two chambers, the lower chamber and the upper chamber. These two chambers are connected with each other by a large valve, called the gate.

The function of the lower chamber is to hold and degas the LCD material. To prevent bubbling and spats the pressure in the lower chamber should be reduced gradually. This is controlled by the recipe and software. To load the LCD material, the tray can be moved upward when the gate is opened and stopped at the location. Details of this chamber are explained in chapter 4.2.

The function of the upper chamber is to hold and degas the empty cells. To this end the empty cells are mounted in a rack. Up to four 1500x1200 mm cells or sixteen 300x300 mm cells can be processed in a single run. To load these cells the upper chamber vessel can be lifted. To prevent glass breakage the pressure in the upper chamber should be reduced gradually. This is controlled by the recipe and software, Details of the upper chamber are explained in chapter 4.1.

Each of the two chamber have their own vacuum pumps, vacuum sensors, pump valves and vent valves. Both vent valves are each connected to a needle valve. This needle valve is manually set on the equipment itself.

For operator control there is a separate screen which replaces the button control panel that is present at Merck Window Technologies filling tool. It contains the buttons necessary for an operator to load/ unload and start the equipment without having to switch to different upper and lower chamber screens. Details are explained in chapter 4.3.

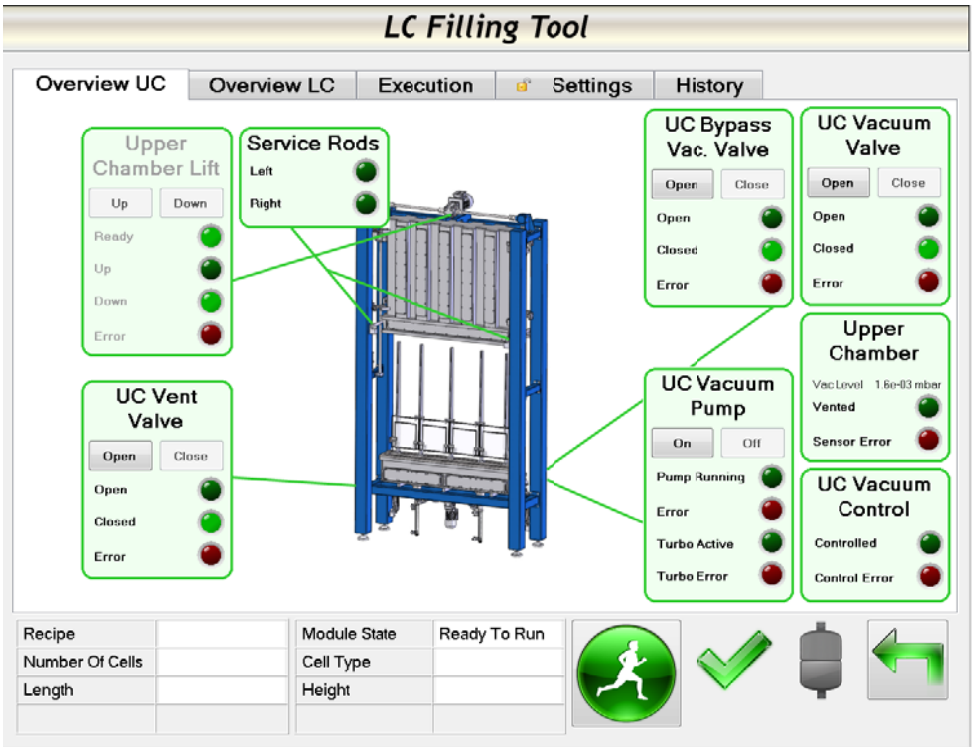
When upper chamber and lower chamber both have finished their degassing process, the gate is opened and the tray with LCD material is moved upward into contact with the ports in the seal. After contact the vessel is vented slowly using the vent valves. After venting, the upper chamber can be opened to remove the filled cells.



The filling tool is not manufactured by 1K3. In this chapter only the software is discussed. For details on operating the filling module please refer to manuals supplied by Masévon, the manufacturer of the equipment.

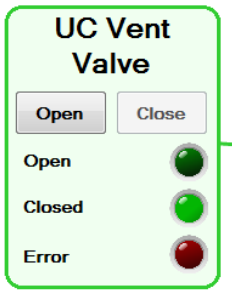
4.1 Overview Upper Chamber

The overview Upper chamber shows a 3D representation of the tool and its components. The screen is shown below. The components of the lower chamber can be found in section 4.2.

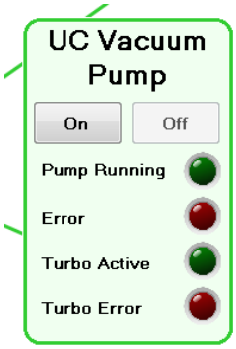


	This component controls the motor that lifts the Upper Chamber Vessel.	
	Up	This button attempts to move the upper chamber up. It is active when lift is not in up position.
	Down	This button attempts to move the upper chamber down. It is active when lift is not in down position.
	Ready	**ON:** The chamber lift is ready for a movement command. **OFF:** The chamber lift is moving or the light curtain is breached, turning off the lift.
	Up	**ON:** The chamber lift has reached the upper limit position. This is the situation that the chamber is fully opened **OFF:** The chamber lift is not in the upper limit position
	Down	**ON:** The chamber lift has reached the lower limit position. This is the situation that the vessel is closed. **OFF:** The chamber is not in the lower limit position, and is not closed.
	Error	**ON:** A time out occurred in the movement of the lift. The upper or lower limit switch wasn't reached on time while the lift wasn't stopped in between. The border will flash red-green. **OFF:** No error.

The position of the lift is controlled by the hardware motor driver. The software starts the movement and monitors the end-stop. In case of a problem, contact the fill tool manufacturer

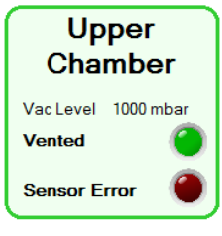


This component controls the Upper Chamber Venting valve.	
Open button	This button attempts to open the Upper chamber vent valve. It is active when the valve is closed.
Close button	This button attempts to close the upper chamber vent valve. It is active when the valve is open.
Open	**ON:** The vent valve is open. **OFF:** The vent valve is not open.
Closed	**ON:** The vent valve is closed **OFF:** The vent valve is not closed.
Error	**ON:** A time out occurred in opening or closing of the valve. Neither open nor closed signal became active after a certain period of time. The border will flash red-green. **OFF:** No error.



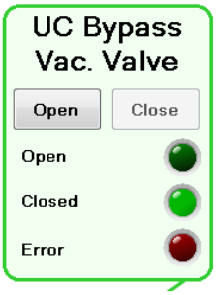
On button	This button attempts to switch on the upper chamber vacuum pump. If the pressure is low enough, the turbo pump is automatically switched on. It is active when the pump is switched off
Off button	This button attempts to switch off upper chamber vacuum pump. It is active when the upper chamber pump is switched on.
Pump Running	**ON:** The UC vacuum pump is running. **OFF:** The UC vacuum pump is switched off.
Error	**ON:** A thermal error occurred in the vacuum pomp. The pump switches off. The border will also flash red-green **OFF:** No error.
Turbo Active	**ON:** The turbo vacuum pump is running **OFF:** The turbo vacuum pump is not running
Turbo Error	**ON:** An error occurred in the turbo vacuum pump. Please check the DCU 400 control panel for details. The border will flash red-green **OFF:** No Error

The turbo pump is controlled by the turbo pump controller unit. This receives a start signal when the pressure inside the upper chamber is lower than minimal 1 mbar. See settings for details of this set point. When pressure is higher than 1 mbar, the turbo pump is automatically switched off.



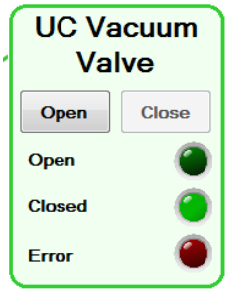
This component controls the Upper Chamber Vacuum sensor.	
Vacuum level	This shows the vacuum level in mbar.
Vented	**ON:** The chamber is completely vented (pressure inside vessel is equal to outside pressure) **OFF:** The chamber is not vented but has a vacuum level different from outside pressure
Sensor Error	**ON:** The vacuum level shown is invalid, the border will flash red/green. The Vented signal remains valid **OFF:** The vacuum level shown is valid.

When a sensor error occurs, the pressure will hold the last measured value. This is not the actual pressure. The actual pressure can be anything. The vented signal is also directly taken from this sensor.



This component controls the Upper Chamber Bypass Vacuum valve.	
Open button	This button attempts to open the Upper chamber Bypass vacuum valve. It is active when the valve is closed.
Close button	This button attempts to close the upper chamber Bypass vacuum valve. It is active when the valve is open.
Open	**ON:** The bypass vacuum valve is open. **OFF:** The bypass vacuum valve is not open.
Closed	**ON:** The vacuum valve is closed **OFF:** The vacuum valve is not closed.
Error	**ON:** A time out occurred in opening or closing of the valve. Neither open nor closed signal became active after a certain period of time. The border will flash red-green. **OFF:** No error.

The bypass vacuum valve is intended for use as a pumping booster for the Upper Vacuum chamber. It can be opened just like the vacuum valve to increase pumping speed. It closes automatically when the turbo pump is started and cannot be opened while the turbo pump is running



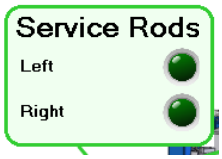
This component controls the Upper Chamber Vacuum valve.	
Open button	This button attempts to open the Upper chamber vacuum valve. It is active when the valve is closed.
Close button	This button attempts to close the upper chamber vacuum valve. It is active when the valve is open.
Open	**ON:** The vacuum valve is open. **OFF:** The vacuum valve is not open.
Closed	**ON:** The vacuum valve is closed **OFF:** The vacuum valve is not closed.
Error	**ON:** A time out occurred in opening or closing of the valve. Neither open nor closed signal became active after a certain period of time. The border will flash red-green. **OFF:** No error.



This component shows the Upper chamber vacuum control.	
Controlled	**ON:** The vacuum control is active and the present vacuum level is within the controlled band. **OFF:** The vacuum control is inactive OR the vacuum control is active and the present vacuum is outside the controlled band.
Control Error	**ON:** Vacuum control was active and the vacuum level run outside the error band. **OFF:** No error.

The upper chamber vacuum control is switched on and off by the automatic program. It can't be activated manually.

The controlled band and error band of the upper and lower chamber vacuum control are taken from the settings.

	This component shows if service rods are placed. Left and right are with regard of the view in front	
	Left	**ON:** The left Service Rod is placed **OFF:** No service Rod is placed in the left holder
	Right	**ON:** The right Service Rod is placed **OFF:** No service Rod is placed in the right holder

The placement of service rods will also result in error messages.

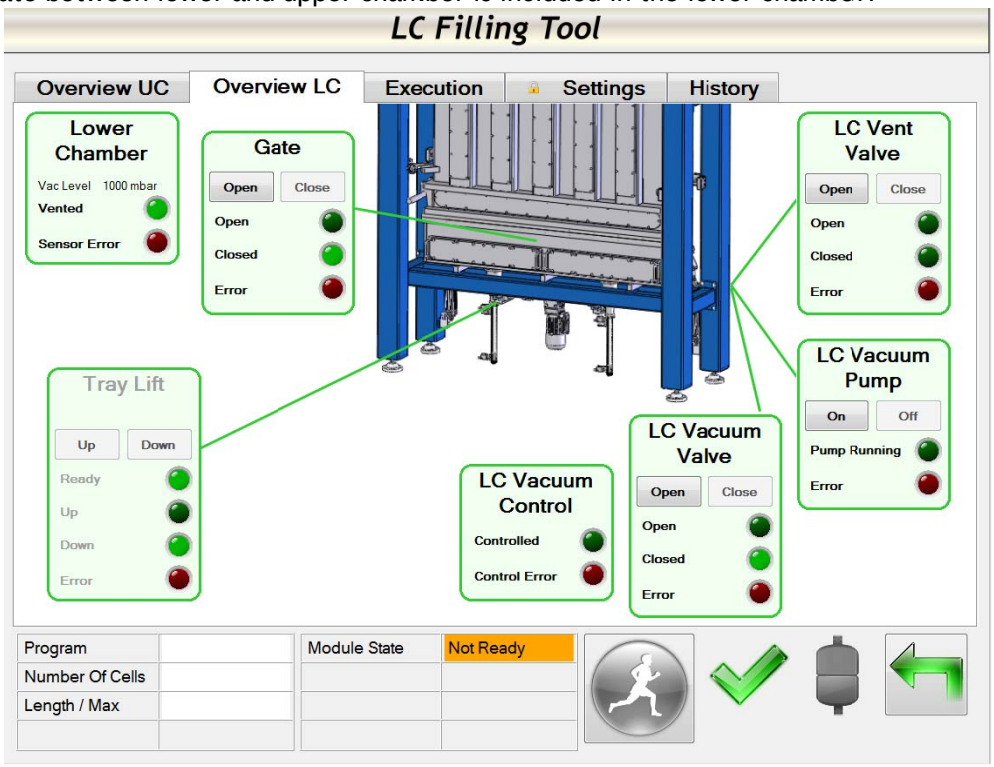
The service rods component is only visible in Supervisor mode.

The conditions that valves are allowed to open, pumps allowed to run and lifts are allowed to move are in the safety and interrupted sections of this chapter.

All component controls are inactive when the automatic process is running. This is also the case for the buttons on the tool. To regain the control the process should either be completed or aborted.

4.2 Overview Lower Chamber

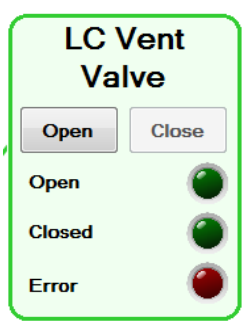
The overview Lower chamber shows a 3D representation of the tool and its components. The screen is shown below. The components of the Upper chamber can be found in section 10.1. The gate between lower and upper chamber is included in the lower chamber.



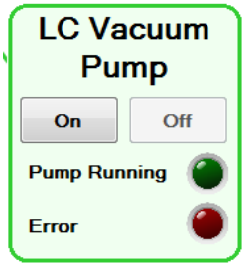


This component controls the motor that lifts or lowers the tray which contains the LCD material.	
Up	This button attempts to move the tray up. It is active when the tray is not in up position.
Down	This button attempts to move the tray down. It is active when the tray is not in down position.
Ready	**ON:** The tray lift is ready for a movement command. **OFF:** The tray lift is moving or the light curtain is breached, turning off the lift.
Up	**ON:** The tray lift has reached the upper limit position. This is the situation that the tray is in the cell filling position **OFF:** The tray lift is not in the upper limit position
Down	**ON:** The tray lift has reached the lower limit position. **OFF:** The tray is not in the lower limit position.
Error	**ON:** A time out occurred in the movement of the lift. The upper or lower limit switch wasn't reached on time while the lift wasn't stopped in between. The border will flash red-green. **OFF:** No error.

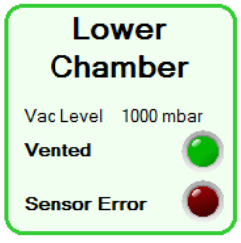
The position of the lift is controlled by the hardware motor driver. The software starts the movement and monitors the end-stop. In case of a problem with the stop location check the end sensors and contact the fill tool manufacturer



This component controls the Lower Chamber Venting valve.	
Open button	This button attempts to open the Lower chamber vent valve. It is active when the valve is closed.
Close button	This button attempts to close the Lower chamber vent valve. It is active when the valve is open.
Open	**ON:** The signal open vent valve is given. **OFF:** The signal close vent valve is given.
Closed	**ON:** The signal close vent valve is given. **OFF:** The signal open vent valve is given.
Error	**UNUSED:** The LC Vent valve doesn't supply any feedback sensors. For the same reason it is not possible to detect its actual state.



This component controls the Lower Chamber Vacuum pump.	
On button	This button attempts to switch on the lower chamber vacuum pump. It is active when the pump is switched off
Off button	This button attempts to switch off lower chamber vacuum pump. It is active when the lower chamber pump is switched on.
Pump Running	**ON:** A switch on signal was given to the pump. **OFF:** A switch off signal was given to the pump.
Error	**ON:** A thermal error occurred in the vacuum pump **OFF:** No Error

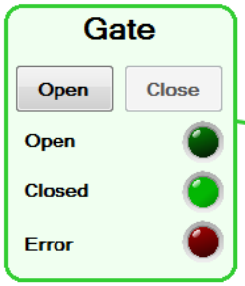


This component controls the Lower Chamber Vacuum sensor.	
Vacuum level	This shows the vacuum level in mbar.
Vented	**ON:** The chamber is completely vented (pressure inside vessel is equal to outside pressure) **OFF:** The chamber is not vented but has a vacuum level different from outside pressure
Sensor Error	**ON:** The vacuum level is invalid. This can also have its effect on the vented signal **OFF:** The vacuum level is valid.

The vacuum sensor can only show values between $1 * 10^{-5}$ mbar and 1050 mbar. Any values outside this range will show either the minimum or maximum value.

When a sensor error occurs, the pressure will hold the last measured value. This is not the actual pressure. The actual pressure can be anything. The vented signal is also directly taken from this sensor.

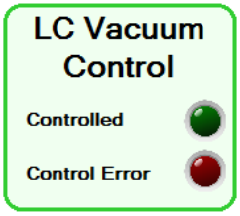




This component controls Gate between lower and upper chamber.	
Open button	This button attempts to open the gate. It is active when the gate is not closed.
Close button	This button attempts to open the gate valve. It is active when the gate is not open.
Open	**ON:** The gate is fully opened. **OFF:** The gate is not fully opened.
Closed	**ON:** The gate is fully closed **OFF:** The gate is not fully closed.
Error	**ON:** A time out occurred in opening or closing of the gate. Neither open nor closed signal became active after a certain period of time. The border will flash red-green. **OFF:** No error.



This component controls the Lower Chamber Vacuum valve.	
Open button	This button attempts to open the lower chamber vacuum valve. It is active when the valve is closed.
Close button	This button attempts to close the lower chamber vacuum valve. It is active when the valve is open.
Open	**ON:** The vacuum valve is open. **OFF:** The vacuum valve is not open.
Closed	**ON:** The vacuum valve is closed **OFF:** The vacuum valve is not closed.
Error	**ON:** A time out occurred in opening or closing of the valve. Neither open nor closed signal became active after a certain period of time. The border will flash red-green. **OFF:** No error.



This component shows the lower chamber vacuum control.	
Controlled	**ON:** The vacuum control is active and the present vacuum level is within the controlled band. **OFF:** The vacuum control is inactive OR the vacuum control is active and the present vacuum is outside the controlled band.
Control Error	**ON:** Vacuum control was active and the vacuum level run outside the error band. **OFF:** No error.



The lower chamber vacuum control is switched on and off by the automatic program. It can't be activated manually.



The controlled band and error band of the lower chamber vacuum control are taken from the settings.



The conditions that valves are allowed to open, pumps allowed to run and lifts are allowed to move are in the safety and interrupted sections of this chapter.

All component controls are inactive when the automatic process is running. This is also the case for the buttons on the operator screen. To regain the control the process should either be completed or aborted.

4.3 Operator Screen.

The operator screen is a software replacement of the button controls present on the first LC filling tool. The different controls are explained below.



	This component is a copy of the start and stop button. It also has two indicator light.	
	Start button	Pressing this button will start the process. It has the same function as the green start button below the module.
	Stop button	Pressing this button will stop a running process or stop a movement of gate, tray lift or upper chamber lift
	Start button light	**GREEN:** The LC Fill tool is ready for start. **GREEN FLASHING:** Process is completed **DARK GREY:** The LC Fill tool is not ready for start. Start button is inactive **YELLOW:** confirmation that a green button is pressed **BLUE:** confirmation that a grey button is pressed
	Stop button light	**RED:** The stop button is active. Pressing it will stop a running process. **RED FLASHING:** The tray and upper chamber motor are inactive. **DARK GREY:** No running condition **YELLOW:** confirmation that a red button is pressed **BLUE:** confirmation that a grey button is pressed

	This component show the vented lights. These are no buttons	
	UC Vented	**GREEN:** The Upper chamber is completely vented. **GREEN FLASHING:** The upper chamber has reached the vented condition and is now adding nitrogen to the chamber to create an overpressure. This lasts for two minutes. **DARK GREY:** The Upper chamber is not vented
	LC Vented	**GREEN:** The lower chamber is completely vented. **GREEN FLASHING:** The lower chamber has reached the vented condition and is now adding nitrogen to the chamber to create an overpressure. This lasts for two minutes. **DARK GREY:** The lower chamber is not vented

The other components controls the movement of the upper chamber, tray lift and gate	
	Pressing this button will move the upper chamber up.
	Pressing this button will move the upper chamber down.
	Pressing this button will move the LC tray up.
	Pressing this button will move the LC tray down.
	Pressing this button will open the gate. The button will glow blue when pressed
	Pressing this button will close the gate. The button will glow blue when pressed

The buttons are not grayed out when these are not active.

The start and stop buttons on the operating screen are active during the automatic process. These buttons work like the Start/Stop button on the screen. Only one of the two buttons is active. In case the module is in an aborted, done, ready or waiting state, the start button is active. In case the module is in a busy, aborting or interrupted state, the stop button is active.

4.4 Recipe parameters

The purpose of the LC filling tool is to fill the cells with liquid crystal material. To be able to be filled the cells themselves need to be evacuated. To start the process, the state of the equipment should be as follows:

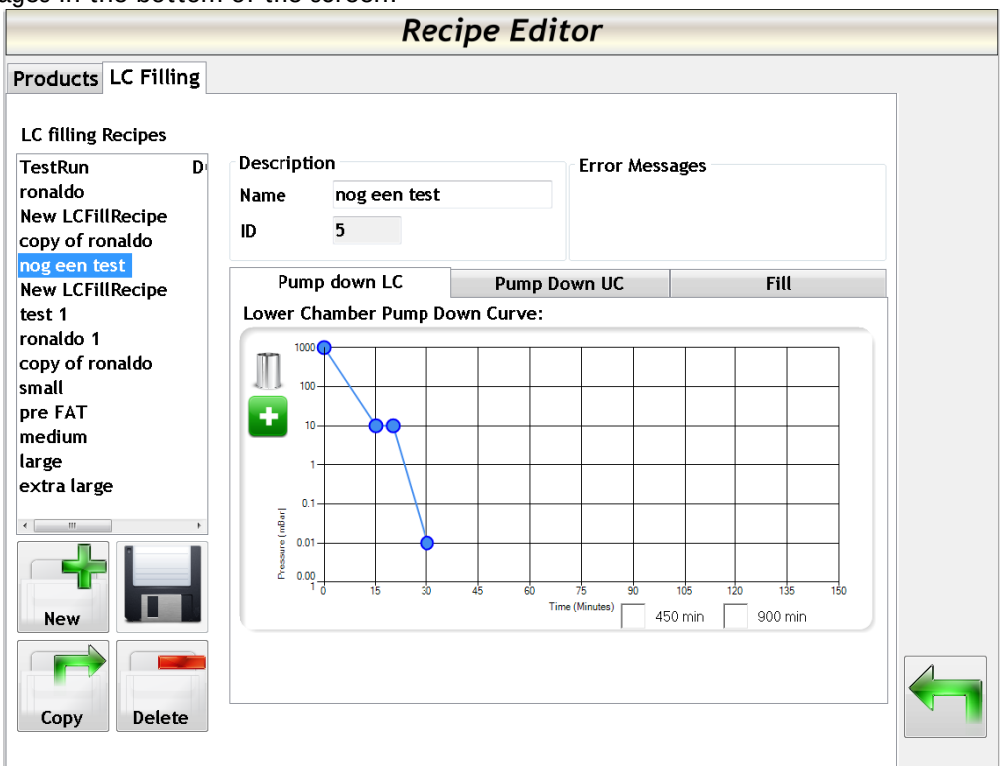
1. The tray is fitted with the right LCD material holder and filled with adequate material. The tray is on its lowest position, allowing the gate to close.
2. The gate is closed.
3. The cells are placed in the cell holders.
4. The upper chamber vessel is in down position and is closed.
5. Both chambers are on atmospheric pressure.
6. The tool is not interrupted by lightscreen or pressed emergency button
7. Preferably, all pumps are shut down and all vent- and valves are closed.

The process flow is as follow:

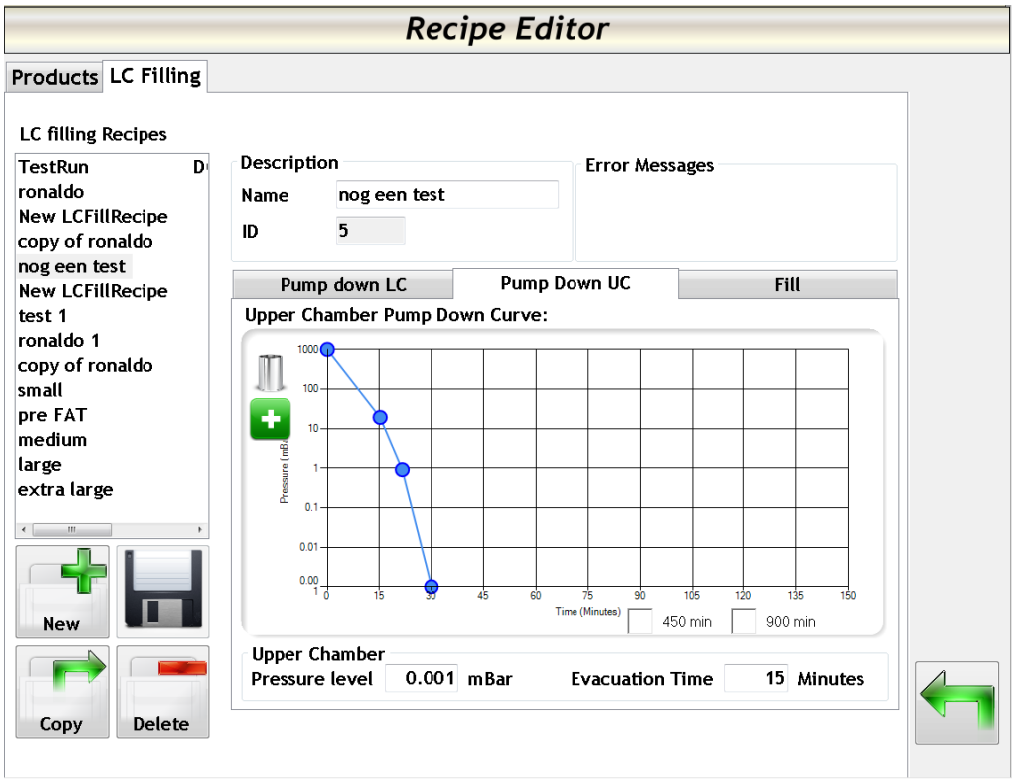
1. The lower chamber will start evacuate using the lower chamber vacuum control to follow the LC vacuum curve set in the recipe. It will follow the curve until the curve is finished in time
2. When the lower chamber pressure is below 100 mPa, the upper chamber starts to evacuate using the vacuum control to follow the UC vacuum curve set in the recipe. It will follow the curve until the curve is finished in time or the pressure is low enough for the turbo to engage.
3. When the pressure in the lower chamber is low enough, it will open the bypass valve to increase pumping speed of the upper chamber pump.
4. When the pressure is low enough, the turbo unit will engage, and lower the upper chamber pressure further.
5. When the upper chamber vacuum level is lower than a preset value, the upper chamber evacuation cycle begins.
6. When the upper chamber has stayed below the preset vacuum level for a preset time, the upper chamber process is finished.
7. When both upper chamber (2-6) and lower chamber (1) processes are finished the next sequence is started:
    a. Both Upper chamber vacuum valves are closed
    b. The upper chamber pump units are shut down.
    c. The equipment waits until the pressure in the upper chamber gets above a settings value, indicating that the turbo has spun down sufficiently.
8. When the pressure in the upper chamber rises above a certain setpoint, the next sequence is started
    a. Lower chamber vacuum valve is closed.
    b. If no pump action is required during venting, the lower chamber pump is shut down.
    c. The gate is opened.
    d. When the gate is fully opened the tray is moved completely upwards.
9. Now the prefill-time starts. During this time the pressure is monitored and allowed to raise up to the last set point in the lower chamber vacuum control. Vacuum control is engaged when this set point is reached.
10. After prefill-time is elapsed, the chambers are vented by supplying dry nitrogen ‘puffs’ by shortly opening the lower chamber vent valve. The openings and closing times of the valve are set in the recipe. If needed the LC pump can run at the same time, to prevent large vacuum level increases. This is vent step 1.
11. A total of 3 different pulse levels can be set to increase venting during the process. These are vent step 1 , 2 and 3. It is common to have the LC vent valve fully opened during step 3.

12. After step 3 is completed, vent step 4 is started. In this step the UC vent valve is used to create nitrogen 'puffs' by slowly opening and closing the UC ventvalve. Vacuum level increase should be much higher compared to step 1-3.
13. After step 4 is completed, the program ends. In common conditions the chambers should be completely vented.
14. On the end of the program after the vented signal the valves keep open for some time to create a mild overpressure to prevent moisture and other contaminants to enter the vacuum vessel.

Finalizing the venting and raising the vacuum vessel is carried out by the operator, after the automatic program has finished.
To realize this process, a number of variables are available in the recipe editor screen as shown below. Next to the common items like name, ID and error messages log there are three tab pages in the bottom of the screen.



Parameter	Description	Lower bound	Upper Bound
Name	Name of the recipe	At least 3 characters	-
ID	ID in database	-	-
Checkbox extend to 450 minutes	If checked the axis length of the pump down curve will be 450 minutes instead of the standard 150 minutes.		
Checkbox extend to 900 minutes	If checked the axis length of the pump down curve will be 900 minutes instead of the standard 150 minutes		
Lower chamber pump down curve	The vacuum level curve which is entered in the lower chamber pressure control		

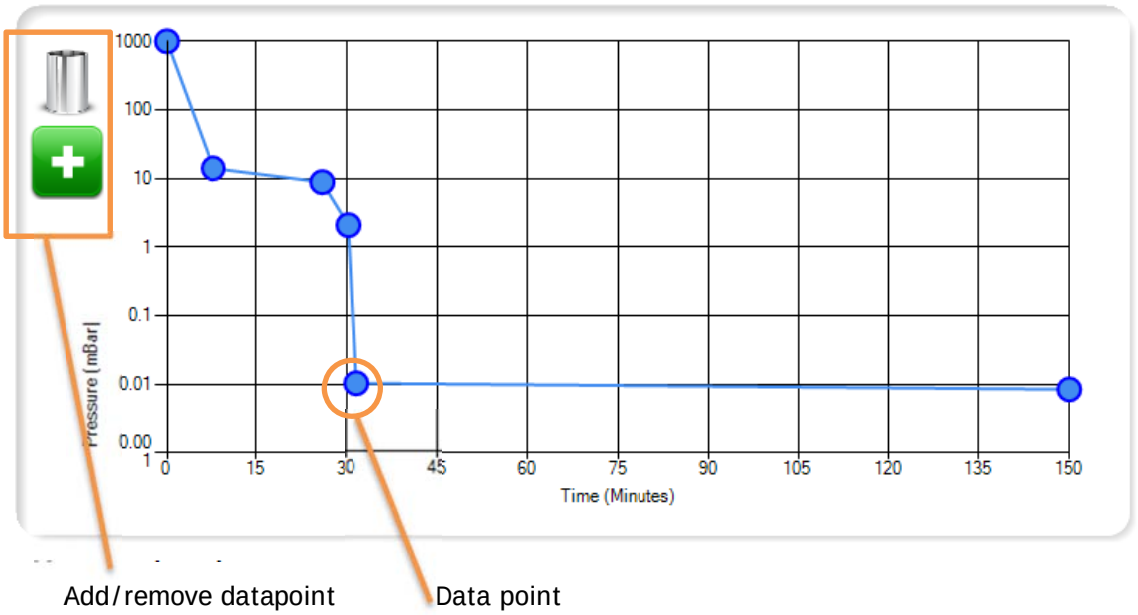


Upper Chamber pressure level	Vacuum level that should be reached in the upper chamber at pump time before evacuation time is started	0,0001 mbar	1000 mbar
Upper chamber evacuation time	Time that vacuum level should be below set pressure level before evacuation is completed	2 Minutes	120 Minutes
Upper chamber pump down curve	The vacuum level curve which is entered in the upper chamber pressure control		

If during the automatic process the upper chamber pressure level is reached, but during the evacuation time the pressure rises to 1,5 times this value, the evacuation time is aborted, and the pressure has to reach the upper chamber pressure level again within 5 minutes otherwise a Time out UC vacuum will occur. If the pressure does reach the upper chamber pressure level again, the upper chamber evacuation time is fully restarted

For example, the evacuation time is 30 minutes and the upper chamber pressure level is 0,001 mbar. After reaching this level and after 20 minutes of evacuation time the pressure rises above 0,0015 mbar. After 5 minutes, the pressure is still 0,0012 mbar, and now the process is aborted with a time out UC vacuum. If after the rise above 0,0015 mbar the pressure drops again below 0.001 mbar after 3 minutes, it has to stay below 0,0015 mbar for another 30 minutes to complete the evacuation time.

Prominently present in the screen are the Lower chamber and upper chamber pump down curve. These curves are used by the lower/upper chamber vacuum control to control the vacuum level over time. The controls for creating and editing the curve are explained below:



Add/remove datapoint Data point

Data point: The curve is made up of a series of data points. A data point is a coordinate containing a time (horizontal axis) and vacuum level (vertical axis). The vacuum level in between data points will be linearly interpolated, just like the curve shown above. Data points can be added and removed. Data points can be edited by dragging them around the graph. If a data point is clicked, it will show the actual time and vacuum level. It can be edited manually and updated.

Add/Remove datapoint: These symbols aren't buttons, but symbols. Contrary to buttons, one should use dragging to create or remove data points as explained below:

	**Delete data point:** Drag a data point on top of this symbol and release it. It is now deleted.
	**Add data point:** Drag this symbol to a location on the graph and a new data point is created. If one uses a key board with mouse, press on this symbol, hold the mouse button down while moving the pointer to a destination on the graph. Release the mouse button.



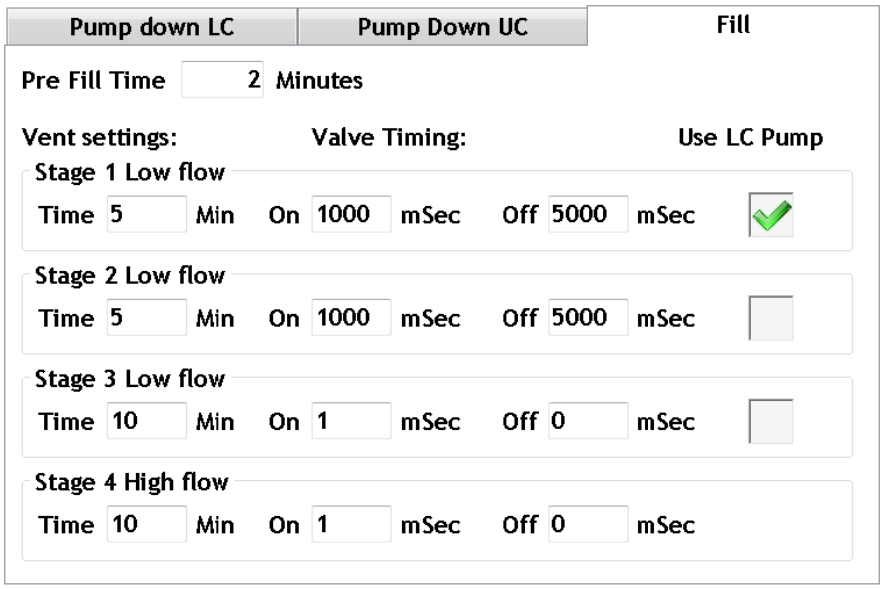
Any curve can be programmed in the recipe editor. This doesn't mean these can actually be executed in the filling tool. Limitations in the system and the settings of the pressure control will adapt the theoretical curve or result into a pressure control failure



The last data point in the curve is also the vacuum level that is used for vacuum control during prefill time. Keep this into account when setting the curve.

The lower chamber vacuum control tries to keep on the set pressure by opening and closing the lower chamber vacuum valve. As soon as the pressure is higher than the control band around the set point, the vacuum valve is opened. It is closed when the pressure is lower than the control band. The valve stays closed until the pressure is higher than the control band, etc.

For the venting, see the fill page below, which is on the last tab page behind the Pump down curve.



The venting parameters are explained below. There are four stages. The meaning of the symbols for each stage is the same, so :

Parameter	Description	Lower bound	Upper Bound
Prefill time	Time for prefilling. During prefilling there is no venting action, but the vacuum control is active	2 minutes	120 minutes
Stage 1-3 low flow and stage 4 High Flow			
Time	Length of the stage. After time has elapsed the stage ends and the next stage begins	1 minute	150 minute
On:	Time the valve is open in milliseconds. Together with the time the valve is closed this is one cycle. After a cycle is completed the valve is opened again for tot	0 ms	600 s
Off:	Time the valve is closed in milliseconds. Together with the time the valve is closed this is one cycle. After a cycle is completed the valve is opened again for tot	0 ms	600 s
Checkbox use LC pump	If checked the lower vacuum chamber pump will switch on during the stage. This option is not available in stage 4.		



In case the off value in a stage is chosen 0 ms, the valve is open all the time.

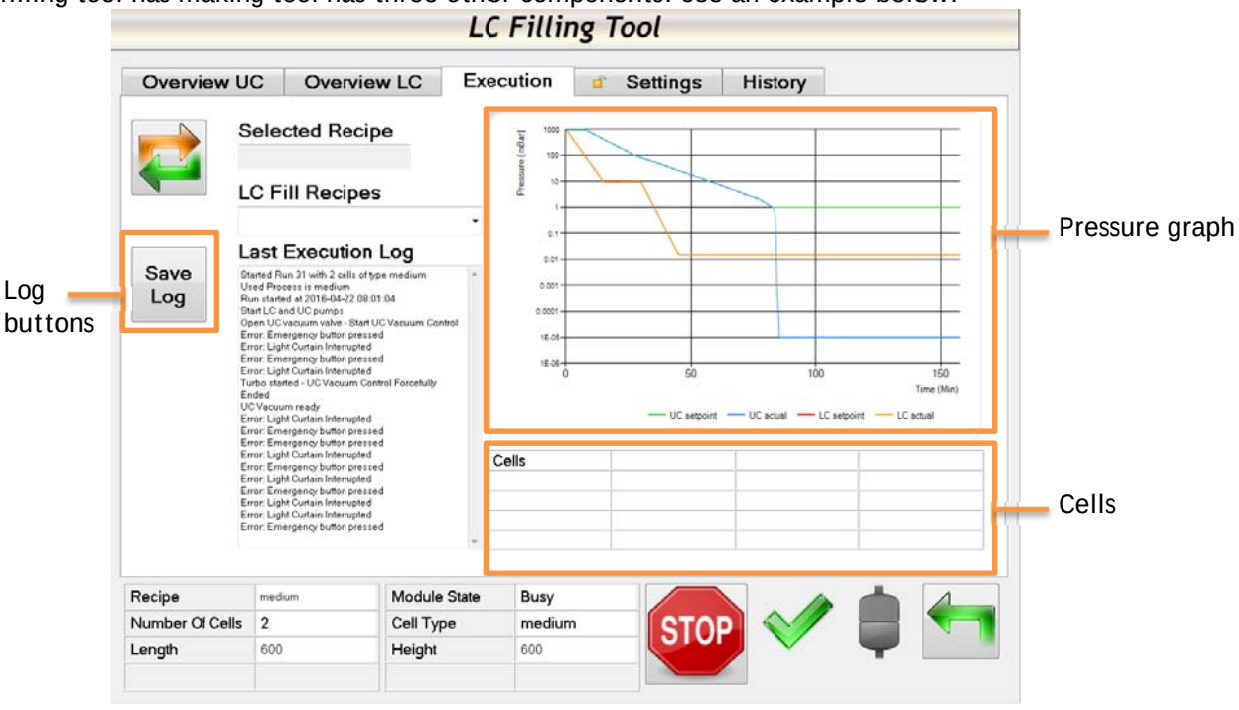
The venting valves need some time to open or close. Setting the opening or closing time too short the valve will not open or close at all. This time is different for the pneumatic lower chamber venting valve and the pneumatic upper chamber venting valve.

Actual venting performance also depends largely on the manual needle valve setting. The manual needle valves are in front of the normal needle valve. The settings on these valves are not checked by the software.

The automatic process ends when the four stages are completed. This is regardless of the chambers have been vented completely. Logging continues until the chambers are vented

4.5 Execution

Next to the common items that are discussed in chapter 2.3 , the execution screen of the LC filling tool has making tool has three other components. See an example below:



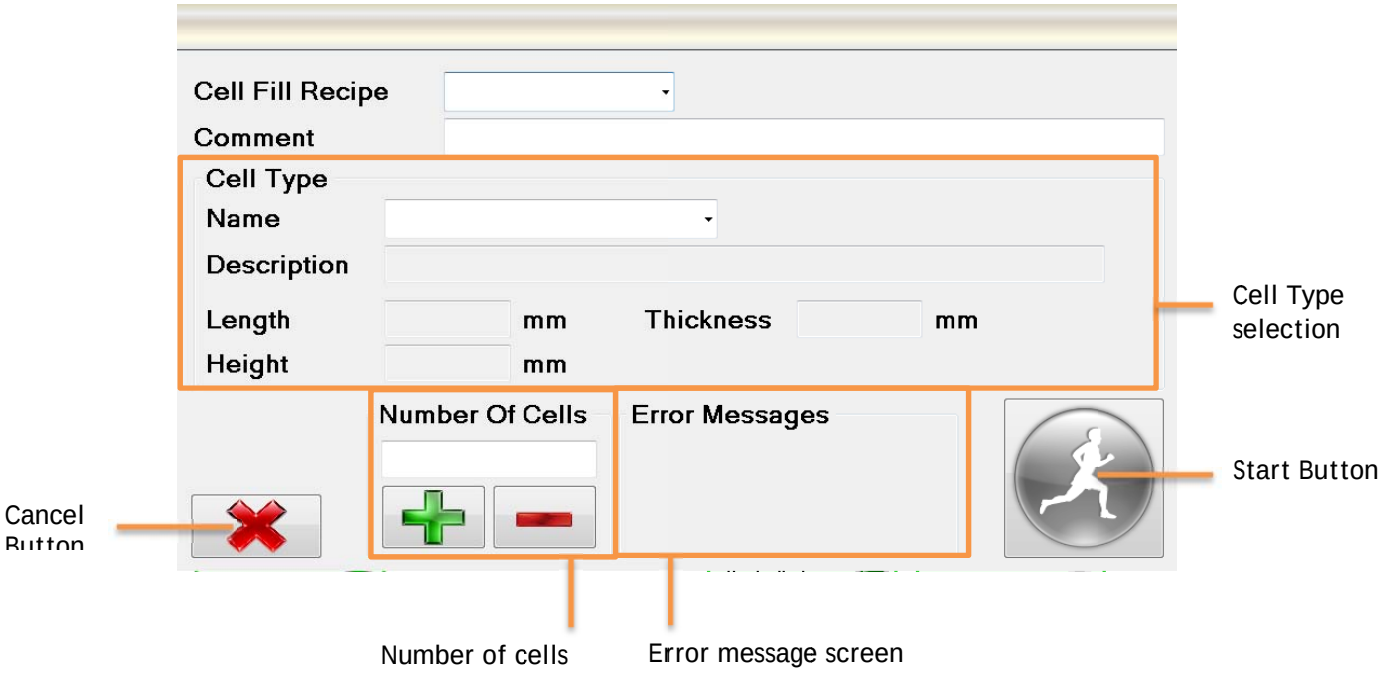
Pressure Graph:	The pressure graph shows the vacuum level of the upper and lower chamber and the setpoints of both the upper and lower chamber vacuum curve. It is automatically started when the automatic process starts. Refresh rate depends on the chosen process. The interval is chosen is such a way that about 2000 points are logged during a run. Interpolation is linear.
Recipe	Present running recipe
Number Of Cells	Number of Cells that are in the LC Fill tool
Length	Length of the cell
Height	Heigth of the cell

Cell Type	Name of de cell type inside the tool
Cells	UNUSED: This shows the list of cell-IDs that are present in the chamber. In this case only one cell is present. Up to 16 cells can be processed at the same time, depending on cell size.
Save Log button	The **Save Log** button will save an image of the graph and a data file in the directory "C:\Logging\". The name of the image file is "log graph" and a date and time of the save moment. The name of the data file is "DataPoints" and a date and time of the save moment. Only the time and pressures are logged.

Data is automatically logged at the end of the process. There is no need to press the save log button during every run.

4.6 Start run window.

When the start button is pressed, a window is opened before the process is started. In this window details of the run can be selected and added. The selection and additions are logged in the tools internal database. See the screen below



Cell Fill Recipe:	This control gives a selection of Cell Fill recipes that are in the database. To enable starting the run, a valid recipe needs to be chosen
Cell Type	This control gives a selection of Cell Types that are in the database. The description, length, height and thickness of the selected cell type are shown in the grey text boxes.
Number Of Cells	Number of Cells that are in the LC Fill tool. This number can be entered in the white textbox, or the number can be increased / decreased by pressing the buttons

	Add a cell to the number of cells in the tool
	Remove a cell to the number of cells in the tool
Comment	In this field details of the run can be entered, identifying tests, special conditions and the like.
Cancel button	Pressing the cancel button cancels the run and closes the screen
Start button	The start button reflects the running state. In case it is grey the input in the start run screen is not valid. If it is green the data entered in the start run screen is valid and pressing this button will close the screen and start the automatic process. In case of a grey symbol, Please check the error message box.



It is allowed to start a run with zero cells, but even with zero cells a valid celltype and recipe needs to be chosen before starting a run is possible



In case of an aborted run, a rerun will also open this screen with the settings of the aborted run. When adapted, the start button can be pressed and a new run will start.

4.7 Settings description

ID	Description	Default value	Unit	Min value	Max value	Explanation
1	Time out time for upper chamber vacuum	60	Min	-	100	This is the maximum time before the preset vacuum level should be reached
3	Relative Control band for lower and upper chamber vacuum control	0.001	-	-	0.2	This is the relative width of the control band. Using the default value and if set pressure is 10 mbar, the control band is 0.01 mbar. If pressure is above 10.01 mbar, the vacuum valve will open.
5	Out of Control band for lower and upper chamber vacuum control	50	-	0.2	100	This is the relative width of the out of control band. If the vacuum exceeds this value, and error occurs. Using the default value and if set pressure is 10 mbar, out of control band is 500 mbar. If pressure is above 510 mbar, the vacuum out of control error is given.
7	Level to switch on Turbo pump	1	mbar	0.01	1	When the vacuum level is below this setpoint, the turbo pump is switched on.
8	Level to open bypass vacuum valve in UC Vacuum control	250	mbar	0.01	1014	To increase pumping speed at lower vacuum levels, the bypass valve can be opened parallel to the vacuum valve. In the first part of the evacuation, the extra pumping speed is not required and will increase the number of valve switches, increasing wear on the vacuum valves.
9	Level to open gate after Turbo spin down	0.0001	mbar	0.00001	0.01	The pumping speed of a spinning down turbo pump is still so high it would significantly influence the vacuum level after opening the gate. To counter this the process waits until the vacuum level is increased above this setting before opening the gate and continue the process



It is admitted that the default values for the vacuum control seem odd, but please regard that the system set-up doesn't really allow for consistent vacuum control in the whole control range. When the valve opens and closes for the first time, the pressure drops from 1000 mbar to less than 100 mbar. To prevent frequent out of control errors and still keep close to the target pressure, the default values have shown to work.

4.8 User level access rights

Item				
Restart process with aborted run		✓	✓	✓
Redo the process on a finished run (DONE state)		✓	✓	✓
Change the recipe in the execution page		✓	✓	✓
Change settings of the tool			✓	✓
Select deleted recipes				✓

4.9 Error description (E = Error, W = Warning)

ID	E/W	Description	Remedy
301	E	**Time out vacuum Upper chamber:** The upper chamber started evacuating, but the set point was not reached after the time-out time had elapsed	Check if the turbo is in an error state Check the pressure curve of the upper chamber. If the turbo was engaged or pressure was still to high to engage the turbo, check for a leak on the Upper Chamber seal or other upper chamber component. Check for contamination on the product that degasses during process. Check if the time-out is set properly
302	E	**Vacuum Level out of Control in {x}:** The vacuum level went outside the out of control band during vacuum control, resulting in a failure. {x} can be Upper chamber or Lower chamber.	Check if the out of control band is set properly Check the pressure curve and determine if the pressure was too low or too high. In case of too low check the vacuum valve function. If too high check the pump system and perform leak testing on the chamber
304	E	**Time Out switching valve in {x}:** The valve mentioned in {x} didn't switch from closed to open or from open to closed after time out time has elapsed. {x} can be Upper chamber vent valve, lower chamber vacuum valve, upper chamber vacuum valve, bypass vacuum valve and the gate.	Abort the program and manually check valve functioning. Is CDA present? In case of the gate, also check the location and functioning of the open and closed sensors. Contact equipment supplier.

305	E	**Time out Motor movement in {x}:** The tray or upper chamber lift failed to reach the upper or down position after time-out time has exceeded. {x} can be either upper chamber lift or the tray lift.	This error can also occur if the motor stopped before sensor position is reached. Is the light curtain breached? Reset the equipment (blue button) and redo movement. Check end point sensor and if problem persist contact equipment supplier
306	E	**Pump error in {x}:** The pump (group) in {x} has reported a failure. {x} can be either lower chamber vacuum pump, upper chamber vacuum pump or turbo pump.	Check the individual pumps for the cause of the problem.
307	E	**Vacuum sensor error in {x}:** The vacuum sensor value is invalid. {x} can be either lower chamber or upper chamber. The value given in such a case is frozen, but the sensor error is active	Check if the vacuum sensors are connected. Check with software designer if communication is correct. In case of a sensor defect, replace the sensor.
308	W	**Light curtain interrupted.** The light curtain was breached, rendering the valves, gate, tray lift and upper chamber lift inoperable	Reset the equipment by pressing the blue reset button.
309	E	**Single service rod is placed in {x}.** The upper chamber can't be moved. {x} can be either left or right. For correct identification face the forward side of the tool.	Place the second rod or remove the rod. In case no rod is present check the rod sensor function. Replace sensors if needed.
310	E	**Both service rods are placed**	In case the upper chamber is closed, remove the rods before moving the chamber upwards.
311	E	**Emergency button pressed.** The emergency button was pressed, which has the same effect as the interrupted light screen.	Unlock the emergency button and press the blue reset button.

Interrupting the light curtain doesn't stop the automatic process. However, the gate can't open and the lift can't move upwards when the light curtain is breached. The automatic process will 'freeze' until movement of gate and tray lift is restored and finish the running process.

4.10 Tool is ready requirements

Item	Required state
Connection	Tool connected
Lower chamber vacuum sensor	Not in a failed state
Upper chamber vacuum sensor	Not in a failed state
Lower chamber vacuum valve	Not in a failed state
Bypass vacuum valve	Not in a failed state
Upper chamber vacuum valve	Not in a failed state
Upper chamber vent valve	Not in a failed state, closed
Tray lift	Not in a failed state, down

Upper chamber lift	Not in a failed state, down
Gate	Not in a failed state, closed
Cells	No cells required
Lower chamber vent valve	Closed
Light curtain	Not breached
Emergency stop	Not pressed



All valves are set in the required position when the automatic process starts.

4.11 Emergency Button procedure

After the emergency button is pressed, please follow the next procedures:

1. Resolve any issues that caused the emergency stop.
2. Restore power by pulling the emergency button.
3. Reset CDA and motor movement by pressing the blue reset button.
4. If needed move the gate to open or closed position.
5. If needed, stop the automatic process. The automatic process can be stopped by pressing the stop button on the operator screen or the stop button on the bottom of the module screen. If not stopped the automatic process will resume if possible.
6. After stopping the automatic process, switch valves or vacuum pumps if needed.



The working of the emergency stop and light screen interruption is almost identical. Pumps are not switched down by the emergency stop and valves will re-open if CDA is restored.

4.12 Safety State requirements

Item	Required state
Emergency button is pressed	If the emergency button is pressed, the next state changed will be carried out: • The gate will stop moving. • The upper chamber lift will stop moving • The tray will stop moving • CDA is locked resulting in vacuum and vent valves to close.
Light curtain breached	If the light curtain is breached, the next state changes will be carried out: • The gate will stop moving • The upper chamber lift will stop moving • The tray will stop moving • CDA is locked and vacuum and vent valves will close
Closing the gate	For closing the gate it is needed that: • The light curtain is not breached • Emergency button is not pressed • The tray is in bottom position (including bottom sensor on)
Lifting the tray	For lifting the tray it is needed that: • The gate is in open position, including open sensor on.

	• The light curtain is not breached • Emergency button is not pressed
Lifting the upper chamber	For lifting the upper chamber it is needed that: • The light curtain is not breached. • The upper chamber is vented. • Either two or no service rod is placed.
Allowed pressure difference between lower and upper chamber and actions as a result. Opening the gate	The lower and upper chamber are connected when the gate opens. When the gate is closed, the gate is hold in a closed position in case the upper chamber pressure is higher than the lower chamber pressure/vacuum level, if the other way around the gate will eventually be forced open. To prevent unwanted problems, the equipment will prevent large pressure differences when the gate is closed. The pressure difference is defined as Upper Chamber vacuum level – lower chamber vacuum level, and if this is: • > 50 mbar: (pressure upper chamber is higher than lower chamber) Gate cannot open. • < -250 mbar: (pressure upper chamber is lower than lower chamber). If gate is closed, upper chamber vacuum pump is switched off, and the upper chamber vacuum valve is closed • < -300 mbar: Upper chamber vent valve is opened, to start equalizing the pressure • < -350 mbar: The gate is opened.
Service Rods	For service on the upper lift a service limit switch is available. It takes over the function of the lower limit sensor. If only one service rod is placed, the upper chamber lift cannot be moved
Turbo pump pollution	If the gate is open, and the lower chamber vacuum pump is running and pressure is low enough, the lower vacuum pump is shut down and the lower chamber vacuum valve is closed to prevent oil from the lower chamber vacuum pump to enter the turbo pump unit
Vacuum pollution	The UC vacuum valve and UC Bypass vacuum valve can only open when the UC Vacuum pump is running. The LC vacuum valve can only open when the LC vacuum pump is running.

To prevent large differential pressures during normal automatic process, the upper chamber starts evacuating only when the lower chamber pressure is less than 100 mbar.

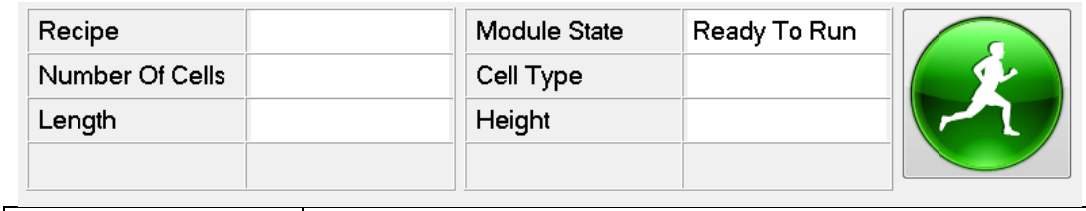
4.13 Interrupted state requirements

Item	Required state
Light curtain	If breached the module is interrupted

Interrupting the light curtain doesn't stop the automatic process. However, the gate can't open, the lift can't move upwards and the valves will close when the light curtain is breached. The automatic process will 'freeze' until movement of gate and tray lift is restored (by pressing the blue button) and finish the running process.

4.14 Bottom row table description

The bottom row table is shown below:



Item	description
Recipe	Name of Present selected LC filling recipe.
Number of cells	The number of cells in the tool.
Length	The length of the selected Cell Type
Height	The height of the selected Cell Type
Cell type	Name of present selected cell type

4.15 Meaning of button and beacon lights

The tool has a beacon light with green, red and blue section and a button lights behind the start and stop button. The meaning of the light signals is explained below.

Signal Beacon lights	description
Red, blue and green are flashing	System is locked
Green is off, Red is on, blue is flashing	An error occurred
Blue is flashing, red is off, green is off	Light curtain has been breached
Green is on	Normal situation
Blue is on	Not ready state