NEMO Name: Tube-OxAnneal-Regular, Tube-OxAnneal-Flex, Tube-OxAnneal-Clean

Location: L02
Category: Anneal/Oxidation
Contact: Ben Newcomb, Dennis Ward, Eric Lim

Contents

1 Introduction 2
1.1 Tube-OxAnneal-Clean (Pyro Ox LOTLC) 2
1.2 Tube-OxAnneal-Flex (Pyro Ox WFG) 2
1.3 Tube-OxAnneal-Regular (Pyro Ox) 2

2 Safety 3

3 User Qualifications and Responsibilities 3

4 Procedure 3

5 Appendix 9
5.1 Aborting a Process 9
5.2 Editing Process Variables 10
5.3 Troubleshooting 11



Figure 1: Multi-Reactor Setup. From top to bottom: Clean, Flex, Regular.

1 Introduction

The CTR-200 Expertech atmospheric furnaces are designed to grow thermal SiO_2 in the temperature range of 800-1050° C. Wet oxidation is available using a pyrogenic reaction with H_2 and O_2. The furnaces can also be used for annealing, film densification, wafer bonding, and sintering. Multi-step process recipes with specified time and gas flows can be programmed using the Multi Reactor Manager (MRM) process recipe editor. Wafers are loaded in a quartz boat then placed on a cantilevered load arm. Our goal is to keep these furnaces as clean as possible. If there is a process or material that is not listed as approved, discuss with staff so that we can evaluate processing options and the potential contamination effects on other processes.

1.1 Tube-OxAnneal-Clean (Pyro Ox LOTLC)

This reactor is suited for clean gate oxides and all substrates require an RCA clean within four (4) hours of loading to the furnace. No metals are allowed in this tube, even if they are embedded below another material. Only wafers should be used, no pieces. The available gases are nitrogen (N_2), hydrogen (H_2), and oxygen (O_2). Processes should not exceed 1050° C for more than four (4) hours or 1000° C for more than eight (8) hours.

1.2 Tube-OxAnneal-Flex (Pyro Ox WFG)

Metals are allowed but require approval. Gold, tin, copper, and zinc are disallowed. An RCA clean within four (4) hours of loading to the furnace is recommended. Pieces and wafers are allowed. The available gases are nitrogen (N_2), hydrogen (H_2), oxygen (O_2), argon (Ar) and forming gas (95% N_2 / 5% H_2). Processes should not exceed 1050 ° C for more than four (4) hours or 1000° C for more than eight (8) hours.

1.3 Tube-OxAnneal-Regular (Pyro Ox)

Metals, including gold, are allowed as long as the process temperature is sufficiently below their melting points. A piranha clean within four (4) hours of loading to the furnace is recommended. Pieces and wafers are allowed. The available gases are nitrogen (N_2), hydrogen (H_2), oxygen (O_2), argon (Ar) and forming gas (95% N_2 / 5% H_2). Processes should not exceed 1050 ° C for more than four (4) hours or 1000° C for more than eight (8) hours.

The general restrictions per reactor are summarized in the table below. These can be used to guide your choice of which tool to add to your process. Tool owners and PTC have final say on tool selection.

Table 1: Summary of the general restrictions for each reactor.

	Material Restrictions	Allowed Substrates	Recommended Clean
Clean	No metals	4”, 6”, 8” Wafers	Full RCA (required)
Flex	No Au, Cu, Sn, Zn	Pieces, 4”, 6”, 8” Wafers	Full RCA
Regular	Metals allowed	Pieces, 4”, 6”, 8” Wafers	Piranha

2 Safety

Hazards present in the system are high-temperature parts, possible pinch/crush points, high voltage, and pressurized gases. Parts and samples can be at high temperatures during and after processing. Exercise care when unloading samples from the chamber. Mechanical pinch/crush points exist with the reactor door. Please keep your fingers and other body parts clear when closing the door to the chamber. N_2 and forming gas displace oxygen and can cause rapid suffocation. O_2 is a strong oxidizer and can cause or intensify a fire. Under normal operation, the user is protected from these hazards by the system software, tool panels and interlocks, and the Toxic Gas Monitoring System (TGMS). Do not attempt to open or remove any panels or interlocks, as you risk exposing yourself and others to these hazards.

If the tool is behaving dangerously or making loud noises, press the red EMO button, alert the staff, and shut down the system in NEMO. DO NOT attempt to re-energize the tool.

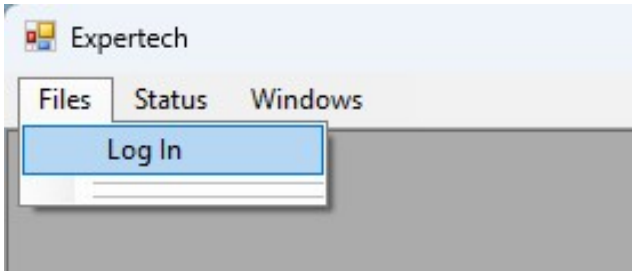
3 User Qualifications and Responsibilities

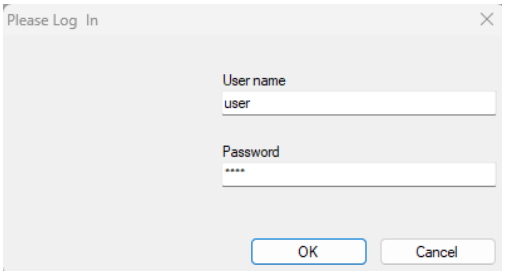
During training, you will learn to load samples and run recipes. To be considered qualified, you need to be trained by the staff in charge, be up to date with your safety trainings, and have a PTC-approved process. Ideally, samples will have an RCA clean directly prior to loading. If your samples cannot withstand RCA, contact the tool owners for possible cleaning methods. Users must review the allowed materials for each reactor in the introduction above. Photoresist is not allowed in the system and organics are prohibited. Circumventing these restrictions or running processes/materials that have not been approved by the PTC can lead to disqualification from the tool.

Users are expected to remove their samples from the reactor, completely close the door, set the tool to IDLE (chamber door closed, flowing 2 L/min N_2, all zones 400° C), and log out of the operator account when they finish their process. If you encounter any problems or notice anything unusual while operating the machine, report the issue in NEMO so the staff can promptly address it.

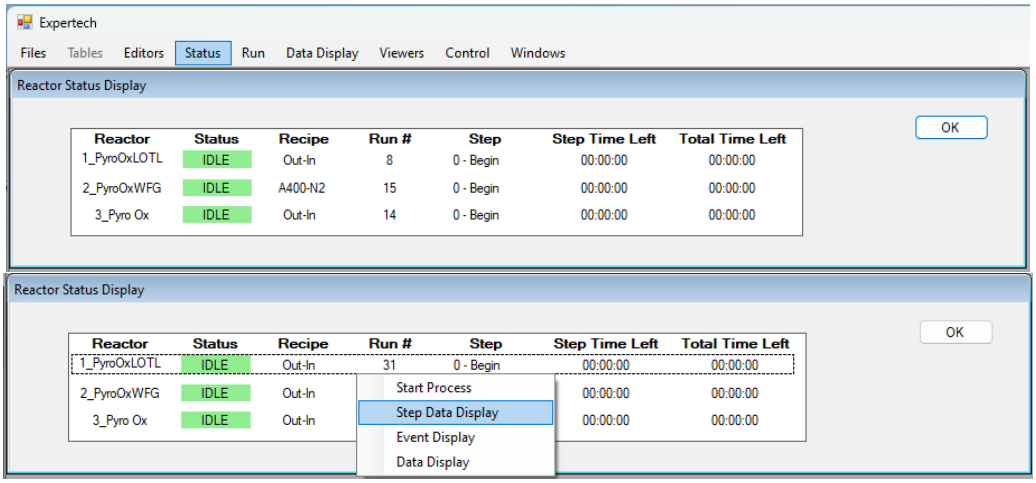
4 Procedure

1. Clean your substrate with respect to the introduction info for the reactor you're using. Check reservations in NEMO to ensure you have reserved the correct tool at the correct time. Engage the tool in NEMO.
2. On the computer, open the MRM (Multi Reactor Manager). In the top left corner of the screen click **Files** then click **Log In**. The operator username is **user** and the password is also **user**.

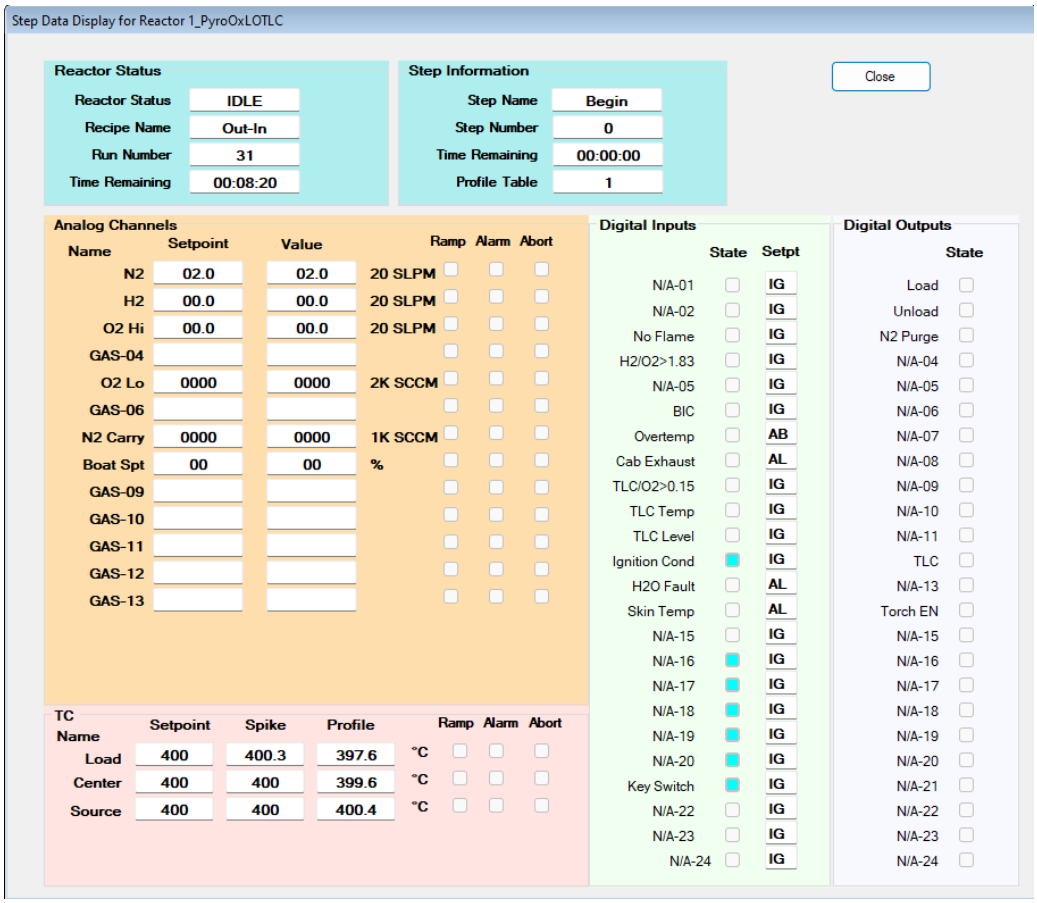




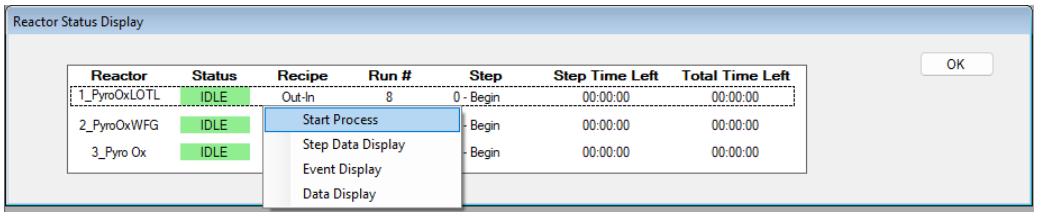
3. Click **Status** on the top toolbar to see information about each reactor. Right click the reactor that you are running your process on and click **Step Data Display** to open the **PCE Process Start** window.



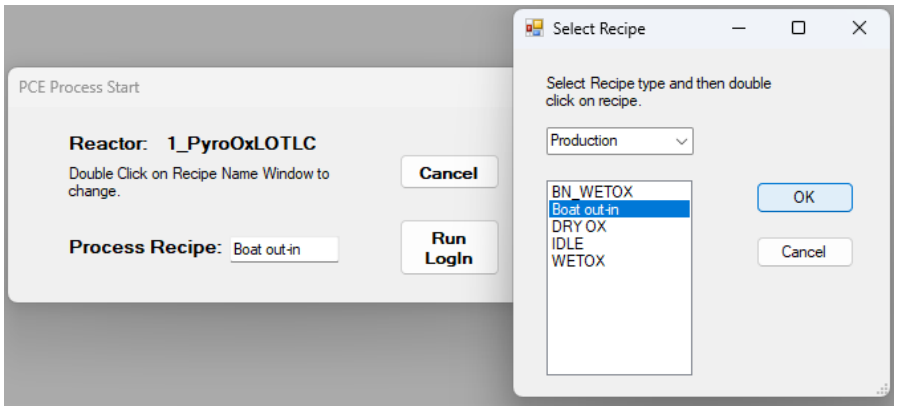
4. It is important to check the gas flow and temperature setpoints before starting a new run or unloading reactor. The display below shows that the reactor is flowing 2 LPM of nitrogen (and no other gases) and is steadily at the idle temperature of 400° C. If something on the data display looks unusual, stop and contact a staff member for help before proceeding.



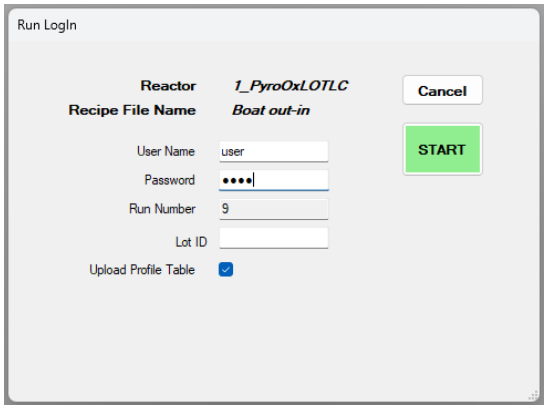
5. In the **Status** window, right click the reactor that you are running your process on and click **Start Process** to open the **PCE Process Start** window. If under the **Step** column in the **Status** window for the reactor you want to use says **59 - Maintenan.**, stop and contact a staff member for assistance.



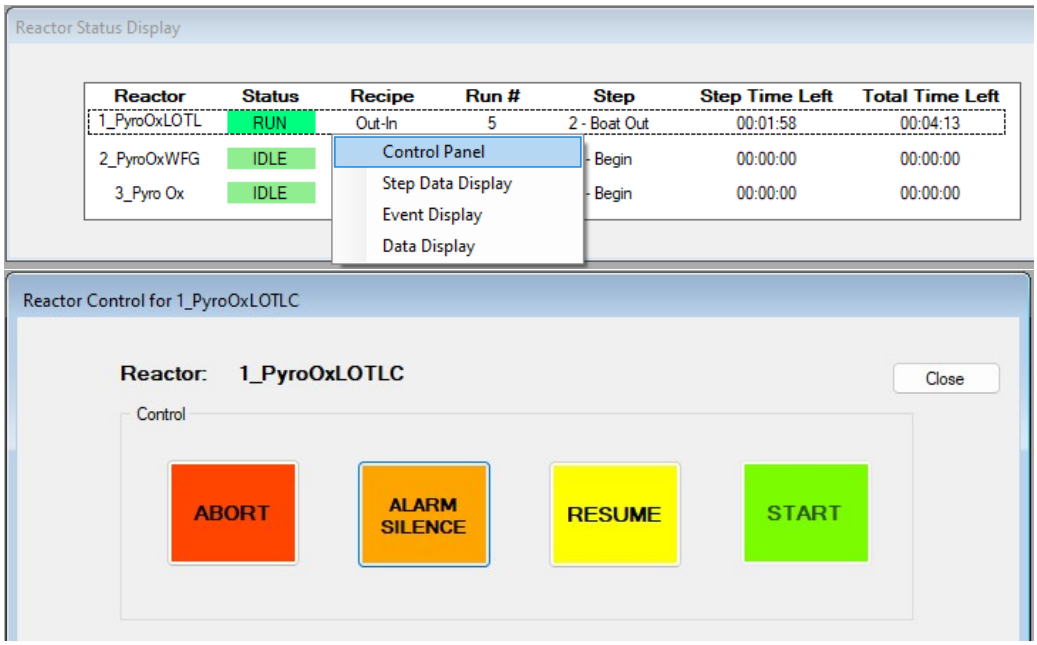
6. In the **PCE Process Start** window, double click the box to the right of **Process Recipe:** to open the **Select Recipe** window. Under the **Production** recipes select **Boat out-in** from the menu. Click **OK** in the **Select Recipe** window, then **Run LogIn** in the **PCE Process Start** window.



7. Enter the username (user) and password (user) into the **Run LogIn** window then click **START**.

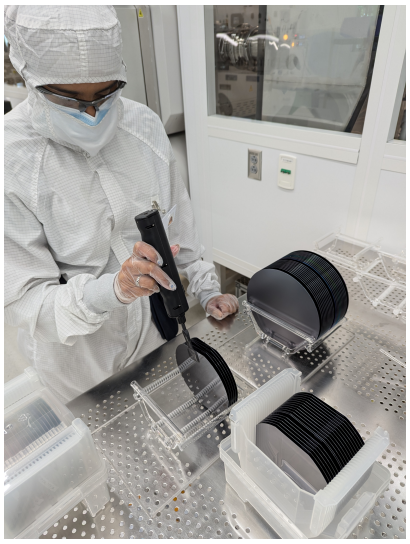


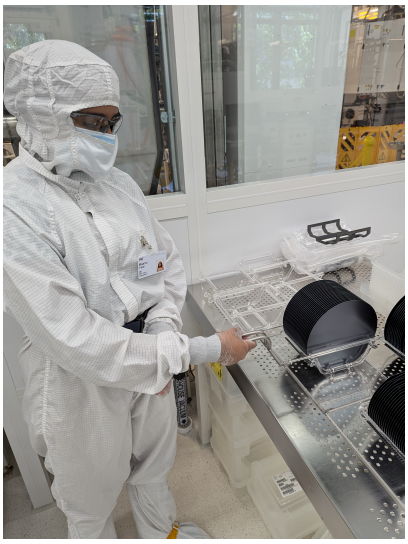
8. Wait patiently as the cantilever door slowly moves out of the tube until it is completely extended. This should take about three minutes if the temperature is below 500° C. The hold step alarm will trigger and the reactor will wait for user input to proceed further. To silence the alarm, right click the reactor you are running in the **Status** toolbar, then select **Reactor Control**. In the **Reactor Control** window, click **ALARM SILENCE**. While the boat is open, you are required to be present in the bay.



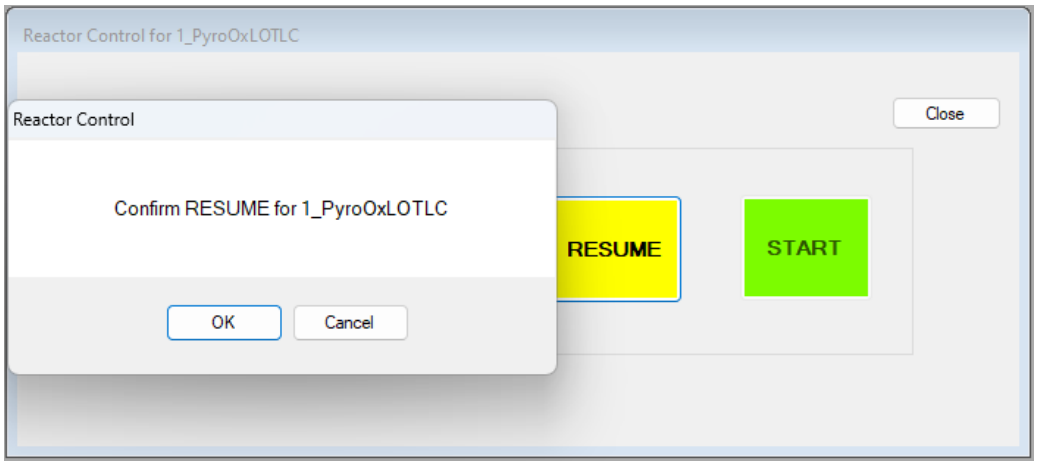
9. Using a quartz tipped metal fork, remove the quartz boat from the cantilever and place it on a quartz plate on the metal table. Wait five minutes for the wafers to cool down. Using a vacuum wand, replace some of the center wafers with your process wafers and take note of which slots you used. All of the available wafer slots in the boat should be filled because the reactor's temperature profiles were calibrated in this condition. Return the boat to the cantilever using the quartz tipped loading fork. For most processes, the process side of the wafer should face the reactor door.







10. In the **Reactor Control** window opened in step 6, click **Resume** and confirm in the pop-up to release the hold. The cantilever will retract into the tube until the door is closed. Wait for the recipe to finish and the reactor status to say **IDLE**.



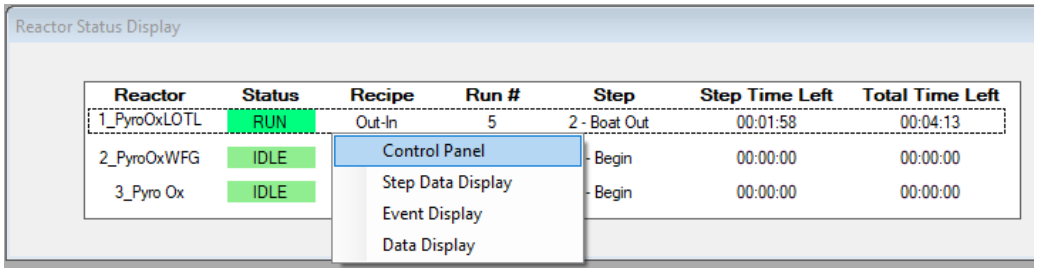
11. Repeat steps 3-7 to start a process, but this time select your desired process recipe from the **Production** tab in the **Select Recipe** window. Review Appendix 5.2 if you need to modify process variables. **For any recipe with process variables, make sure to check the process variable table before every run.**
12. Once your process is complete, repeat steps 3-10 but this time remove your processed wafers from the boat and replace them with the dummy wafers that were removed in step 7. Wait for the recipe to finish and the reactor status to say **IDLE**.
13. Log out of the MRM software by selecting **File** on the top toolbar followed by **Log Out**.
14. Disengage the appropriate reactor in NEMO.

5 Appendix

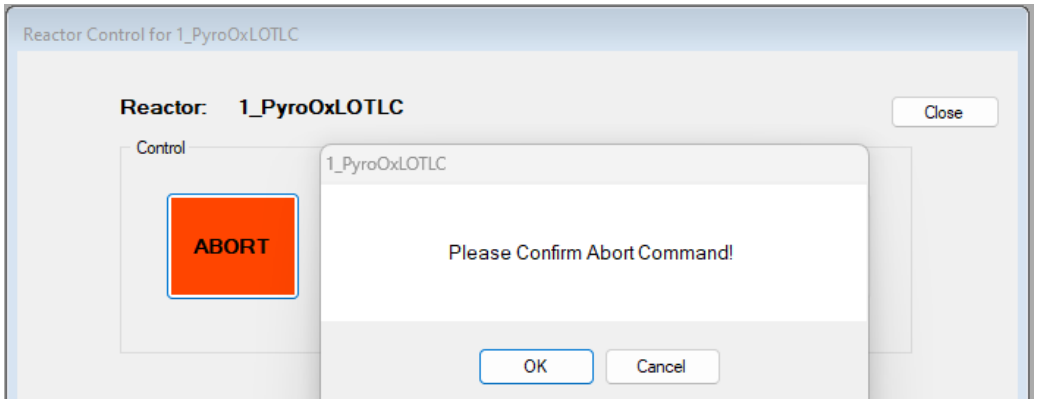
5.1 Aborting a Process

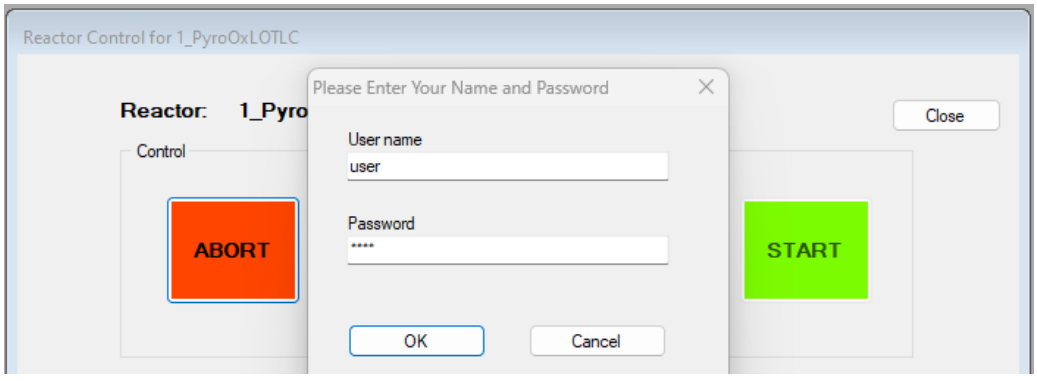
If there is an issue with the reactor, let a staff person know before proceeding. If the tool is behaving dangerously, press the red EMO button to the left of the reactor door, alert the staff, and shut down the system in NEMO.

To abort a process gracefully, right click the reactor you are working on in the **Reactor Status Display**, then select **Control Panel**.



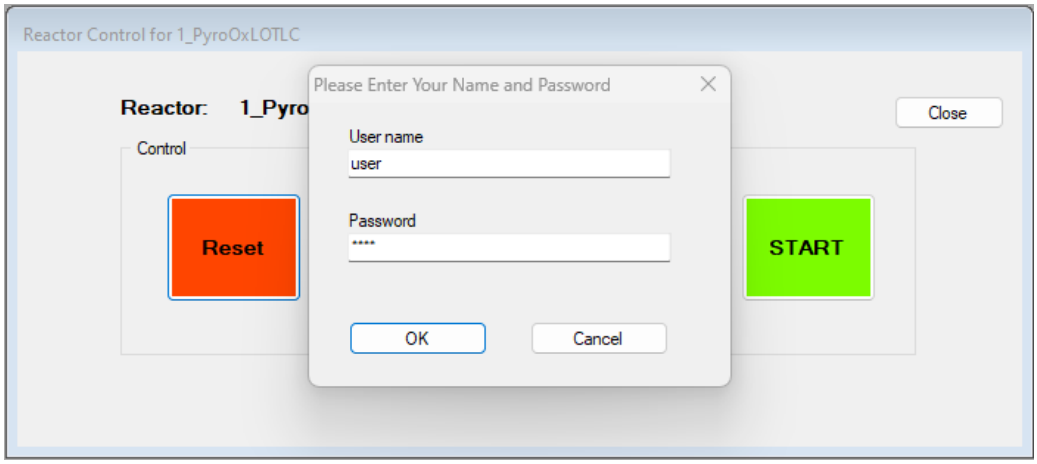
Once the reactor's **Control Panel** is displayed, click the red **ABORT** button. Click **OK** on the confirmation pop-up. Enter the username (user) and password (user) into the dialogue box, then click **OK**.

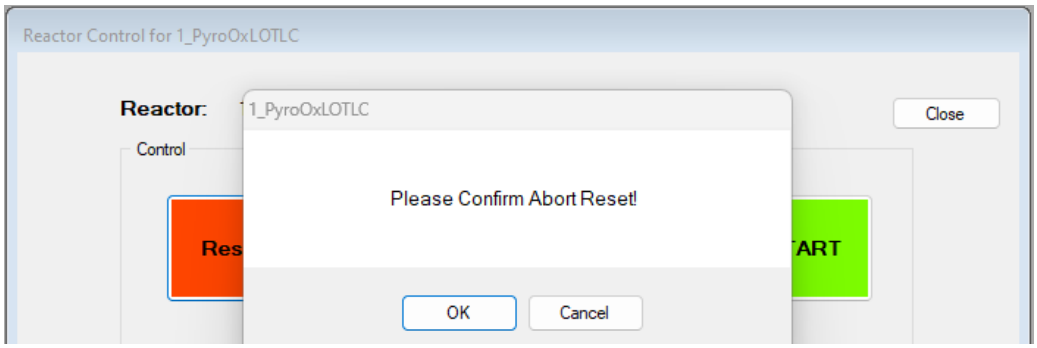




On the **Control Panel**, click **ALARM SILENCE** then proceed to reset the abort to return the reactor to **IDLE**

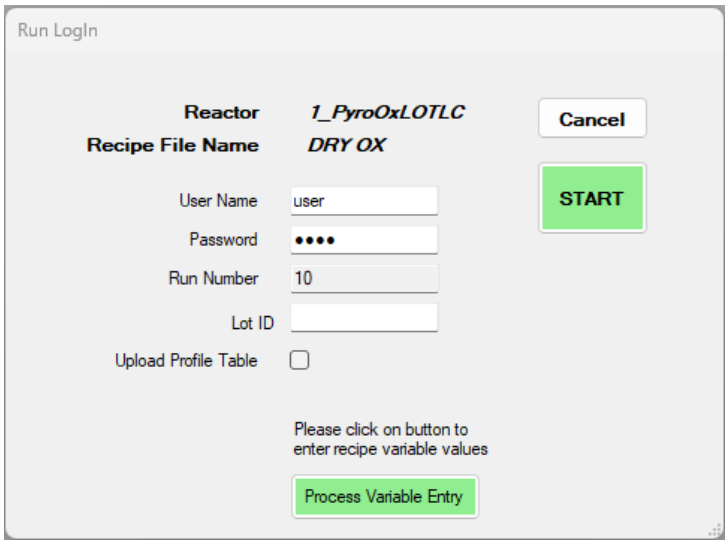
status. Click the red **Reset** button that should have taken the place of the **ABORT** button on the **Control Panel**. Enter the username (user) and password (user) into the dialogue box, then click **OK**. Click **OK** on the confirmation pop-up.



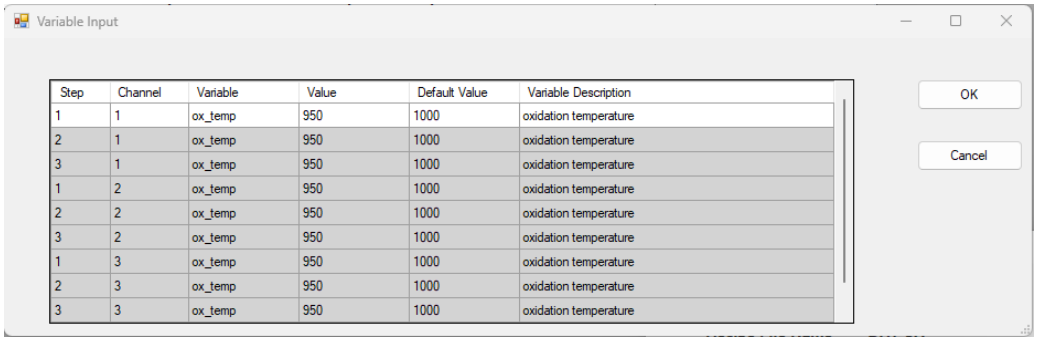


5.2 Editing Process Variables

In some recipes, process variables need to be adjusted to execute your process properly. For example, in the *DRY OX* recipe, it is possible to run the same recipe with variable oxidation temperature and oxidation time. When starting a process, input the username (user) and password (user) into the **Run LogIn** window, then click another input box such as Lot ID. A new green **Process Variable Entry** button will become available.



Click on **Process Variable Entry** to open the **Variable Input** table for the run. As shown in the figure below, there is an adjustable variable, *ox_temp*, with a current value of 950° C. To run at a different temperature, click ”950” in the Value column, in the top row (not the greyed out rows). Type in a new temperature value in Celsius, then hit **Enter** on the keyboard. Scroll down in the table to check/modify any remaining variables (rows highlighted in white) such as *proc_time*.



Step	Channel	Variable	Value	Default Value	Variable Description
1	1	ox_temp	950	1000	oxidation temperature
2	1	ox_temp	950	1000	oxidation temperature
3	1	ox_temp	950	1000	oxidation temperature
1	2	ox_temp	950	1000	oxidation temperature
2	2	ox_temp	950	1000	oxidation temperature
3	2	ox_temp	950	1000	oxidation temperature
1	3	ox_temp	950	1000	oxidation temperature
2	3	ox_temp	950	1000	oxidation temperature
3	3	ox_temp	950	1000	oxidation temperature

After checking that all variables are correct, proceed by hitting **OK** and starting the process.

5.3 Troubleshooting

5.3.1 Difficulty Closing Door

In the **Production** tab of the **Select Recipe** window, all reactors should have a process labeled **Boat-In**. Abort the current process if necessary, then run the **Boat-In** process. If you have further difficulty, contact staff for assistance.

5.3.2 IDLE State

Always leave the reactor with the door completely closed and 2 L/min N_2 flowing at the specified idle temperature before disengaging in NEMO.

5.3.3 Nonsensical Values in Step-Data Display

Sometimes in the **IDLE** state, the **Step Data Display** may give nonsensical values (ex. random numbers for all gas flows). To correct this, run the **IDLE** recipe in the **Production** tab of the **Select Recipe** window. If you have further difficulty, contact staff for assistance.

5.3.4 Windows Login

The Windows username is **user** and the password is also **user**.