Chapter [5.36]

YES Vacuum Oven

(vacoven) **(582A)**

1.0 ***Equipment Purpose***

1.1 The YES (Yield Engineering Systems) Vacuum Cure Oven. This document describes the operational procedures for the YES oven standard programs (1 - 4); how to enter new programs, what materials are allowed and/or forbidden in the oven, as well as user-level troubleshooting guidelines for the tool.

2.0 ***Material Controls & Compatibility***

2.1 The YES oven can be used for curing of polyimides, anneal processes, and other materials which require elevated temperatures of up to 450°C and controlled atmosphere (N2, O2, Ar or forming gas) of between 200 and 400 Torr.

2.2 YES field engineer recommended N2 pressure between 200 and 300 Torr. Lab members are encouraged to give more inputs as more usage of the oven develops a more mature process.

3.0 ***Training and Applicable Documents***

3.1 Basic Tool -this tool requires enabling and a formal qualification session, but does not have an online test.

3.1.1 Timeline (estimated time to completion: 1-2 days)

1. Get trained by any qualified member.
2. Arrange a qualification session with a superuser to show competency on the tool.
3. Superusers and staff qualify members on this tool. Superusers on this tool may have permission to do advanced techniques

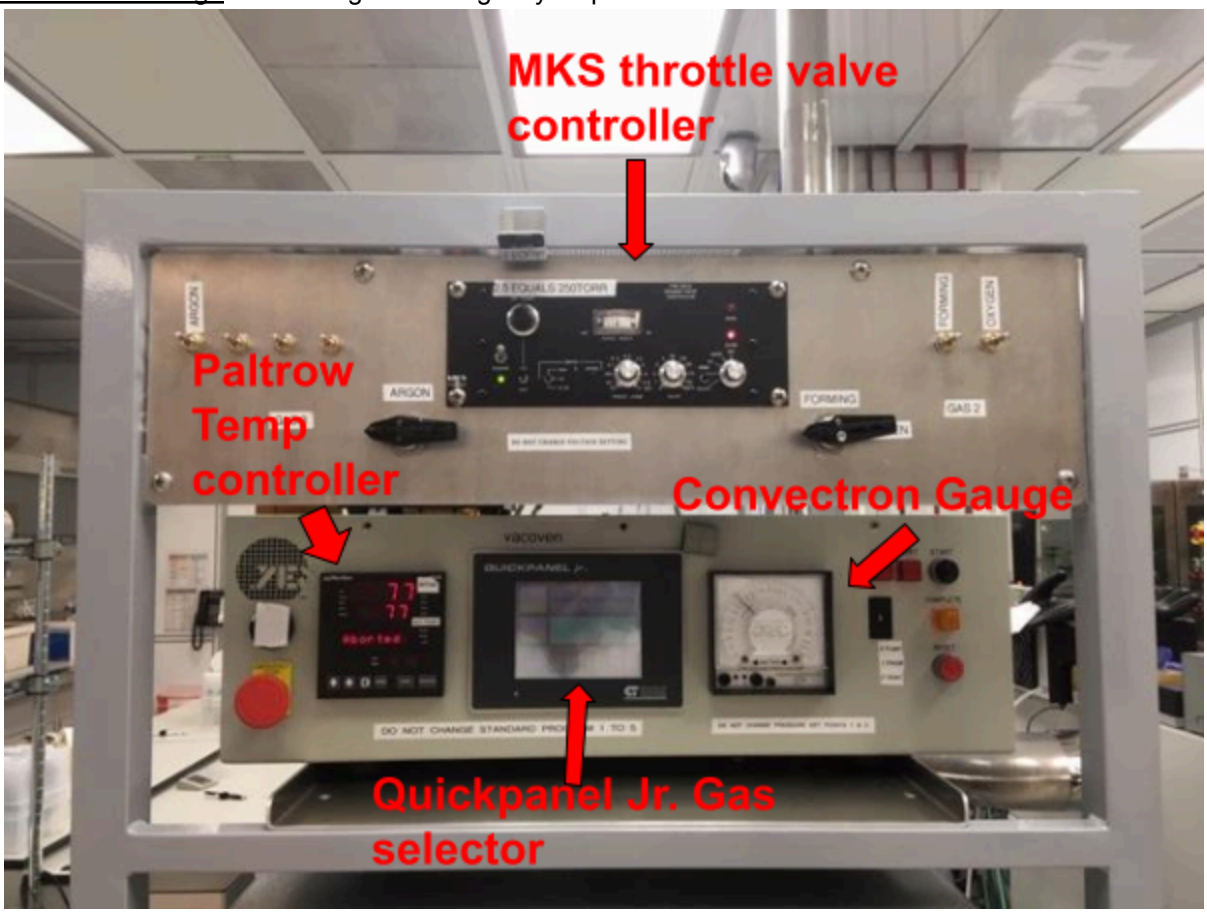
3.2 There are two manuals for the YES oven available upon request in the Nanolab office.

3.2.1 The Partlow MIC 1460 operator manual details the use and programming of the Partlow temperature controller.

3.2.2 The YES-450PB6 / 8-2P-CP operator manual is more focused on the use of the touch screen panel on the system controller. (There are some inconsistencies between the YES manual and the Nanolab tool since this YES oven had been customized by its previous owner.)

4.0 *Definitions & Process Terminology*

4.1 **Control unit:** It sits on top of the oven and houses, among other things, the MKS Gas Controller panel, Partlow temperature controller, the QuickPanel jr. touch screen controller, the Convectron Gauge and the big red emergency stop button.



4.2 **Partlow:** A third-party temperature controller installed in the control unit. This is where temperature as a function of time portion of a process program is entered. (Process gas selection is done on the touch screen and process pressure is specified using a combination of the touch screen and a manually adjustable vacuum throttle.

4.3 **Convectron Gauge:** Granville Phillips 275 Convectron Gauge displays the status of the chamber pressure.

4.4 **MKS Mass Flow Controller -** this controls the amount of gas in the chamber through the throttle valve. The setting doesn't need to be adjusted by users.

4.5 **Touch Screen:** QuickPanel jr. touch screen controller by Control Technology Corporation displays the process status, alarm warning messages, input number of dehydration loops, input time to reach process pressure, vacuum and gas selections.

4.6 **House Vacuum:** Typically selected as Process Vacuum. One of the two vacuums used to pump down the vacuum chamber. The house vacuum, located in the rear of the oven, has a throttle valve installed between the pump and the oven. If decided to use the house vacuum, adjusting this valve is one way of obtaining the desired process pressure.

4.7 **Main Vacuum:** The other vacuum used for pumping down the vacuum chamber. It uses the same rough pump as the house vacuum and is connected in parallel with the house vacuum to the oven. The main vacuum is not throttled and should be selected when lowest pressures are desired.

4.8 **Dehydration Loops:** NOTE: Select BOTH on Quickpanel Jr. for Dehydration Vacuum. Pumps and N2 purges performed at the start of any process used to remove moisture and oxygen from the chamber, prior to starting an anneal process. You may specify how many dehydration loops to execute for your process. Please, note that the temperature program, as specified on the Partlow, does not wait for the dehydration loops to complete before executing your process. You must factor the time it takes for the dehydration loops to execute into your (temperature) program. Each loop takes about ~ 1 minute 15 sec. Based upon 3 dehydration loops, the amount of oxygen from room air left in the oven is estimated at 10 ppm.

4.9 **DIAL settings:** Position of the numbered index wheel on the far right of the oven control panel.

4.9.1 Position 0 = PROCESS Program when above 500T. If not above 500T the oven will first vent.Reset and press Start again when above 500T

4.9.2 Position 1 = Pump

4.9.3 Position 2 = VENT or chamber backfill

4.9.4 Other settings not operational.

5.0 ***Safety***

5.1 **Burn Hazard. Items can be dangerously hot coming out of the oven. The oven walls will also be hot. Wear appropriate hand protection and watch that you do not brush your arm against the oven walls (especially the inside of the oven door) when you unload your wafers.**

5.2 **Do not use Aluminum foil to cover chamber platform because this will block the input/output gas flow which may cause equipment and process issues.**

6.0 ***Statistical/Process Data***

6.1 This tool is not regularly monitored by staff

7.0 ***Available Processes, Gases, & Process Note***

7.1 Available Processes

7.1.1 The YES oven has three major process offerings: Polyimide cure, Anneal, Oxidation. Programs 1 – 4 on the Paltrow (See Appendix) can be used for these processes. They are not to be changed by the user. Programs 6 – 8, on the other hand, are designated for user modification. Note these Program numbers refer to the Partlow temp controller program number and are not to be confused with the thumbwheel positions. The oven will follow Partlow temperature control only when the thumbwheel is set to position 1

7.1.2 Standard PIMD multistep anneal Program #1 at 450°C in YES manual

7.1.3 Program #2 - 200°C, 30 min anneal

7.1.4 Program #3 - 300°C, 30 min anneal

7.1.5 Program #4 - 400°C, 30 min anneal

7.2 Available Gases

7.2.1 Nitrogen

7.2.2 Oxygen

7.2.3 Argon

7.2.4 Forming Gas H2/N2 (10%/90%)

7.3 Process Notes

7.3.1 The standby temperature of the YES oven is currently set to 75°C.

7.3.2 The oven is configured to operate at temperatures between room temperature and 450°C. Attempts to exceed this temperature will fail with an alarm.

7.3.3 The system is optimized for operation between 300 and 450°C. This is where minimum temperature overshoot (< 15°C typically) will occur.

7.3.4 **To prevent chamber oxidation, do not use oxygen for processes to go above 300°C**

7.3.5 Granville Phillips convectron gauge set point 1 = 50 Torr and set point 2 = 500 Torr.

7.3.6 N2, house vacuum and main vacuum valves are preset to obtain 200 to 400 Torr, as recommended for the standard polyimide curing process.

7.3.7 4" and 6" wafer boats are available for vacoven users which are both stored under the vacoven.

8.0 ***Operating Procedure***

8.1 Enable the system on the Mercury

8.2 Check the chamber pressure on the convectron gauge.

8.2.1 **Note:** Make sure oven pressure is 760 Torr so that you can open the chamber door (if not, dial thumb wheel to 2 and press Start. It will inject N2 into the chamber to vent the oven).

8.3 Load samples into oven. Do not put Aluminum foil on chamber surface as a liner. Load wafers on 4" or 6" wafer boat vertically. Insert spatula into boat carrier bottom slot. Put wafers with wafer boat inside the chamber. Remove the spatula and close the door.

8.3.1 **Note:** You may use metal cassette, quartz or graphite boat, when loading wafers. 4" and 6" wafer boats are provided. You may NEVER use plastic (including Teflon™) cassettes nor put plastic into the oven. If you need to use other fixtures for your samples contact Process Engineer 1

8.4 Paltrow Controller: Press **PROF** button until the desired program number is selected on the Partlow temperature controller.

8.5 Quickpanel Touch Screen: Press the **OPERATOR PANEL** button until the **PROCESS PARAMETER SELECT PANEL** page is displayed. On the process parameter select panel, you must indicate the following process details:

8.5.1 DEHYDRATION VACUUM SELECT – This is the vacuum to be used for the dehydration loops. Choose between house vacuum (throttled), main vacuum, and both vacuums. Recommended setting: BOTH

8.5.2 RAMP UP PROCESS GAS SELECT – This is the gas to use whenever the temperature of the oven is increasing. Choose between cold N2, Hot N2 (gas is circulated through heating coils before entering the process chamber), Gas2 -O2 or Forming Gas or Gas3 - Argon. Gas2 and Gas3 options require you to open line valves for each corresponding gas. Recommended – HOT N2.

1. Gas2 - Oxygen or Forming Gas : use the rotating gas selector for Gas 2 to select for Oxygen or Forming Gas. Then flick the ON/OFF toggle switch. Please note that the on/off switches are "off" when the switch is pointing straight out, and "on" when the switch is up, down, left. or right.. "on" has no preffered direction

2. Oxygen/Argon: make sure the valve on the main O2 and/or Ar line is open on the wall. If not sure, call the Process Engineer.

3. Forming Gas: you need to open the gas cylinder valve in the service chase by the Emergency Exit door. If not sure, call the Process Engineer.

Forming Gas Cylinder in chase 591

8.5.3 DWELL PROCESS GAS SELECT – The gas to use whenever the oven is programmed to sit at a given temperature. The choices are the same as above. **NOTE: If you are doing Forming Gas Anneal (FGA) where both RAMP-UP and**

DWELL gas is GAS2 the tool will function as expected. If you want to do FGA and you don't want to use Forming Gas during the RAMP UP step please discuss your process with the Process Engineer. The tool will not switch to Gas 2 just for the dwell step but there is a work around.

8.5.4 RAMP DOWN PROCESS GAS SELECT - This is the gas to use whenever the temperature of the oven is decreasing. Choose between Hot N2, Cold N2 (gas is at room temperature), or both. The heater is actually turned off in the cool down steps. You may select both if you want the greatest amount of room temperature for N2 to cool off your samples.

8.5.5 PROCESS VACUUM SELECT – This is the vacuum to be used after the dehydration loops to, until the selected program has ended. Choose main vacuum or house vacuum (throttled) or both. If you want the lowest possible pressure, choose both to keep the main vacuum valve open. If you want a higher pressure, choose house vacuum and throttle it as needed at the valve for your process. But process pressure must be less than 500 Torr. After your process, you must adjust the throttle valve back to its original position. The default throttle valve position provides process pressure between 200 to 300 Torr. Recommended setting: HOUSE

8.5.6 # DEHYDRATION LOOPS – 3 loops are recommended. Press **ENTER # OF DEHY LOOPS** button on the touch screen panel. Press 3, or the number of loops you decide on (maximum dehydration loops are 9), press **ENTER**, and then press **DONE**.

8.5.7 TIME TO REACH PROCESS PRESSURE – The time to wait for the oven to pump down to below 500 Torr. Recommended time: 120 sec. Press **TIME TO REACH PROCESS PRESSURE** button on the touch screen panel. Enter **120 or your desire time (maximum is 360 sec.)**; press **ENTER**, and then press **DONE**.

8.6 Make sure the touch screen displays **READY TO PROCESS** before starting the process. If not, press the **OPERATOR PANEL** to return to the main status screen manual and the **READY TO PROCESS** will display.

8.7 Set the **DIAL** to **0 (Process)** and press the black **START** button on the system controller.

8.7.1 **Note:** To start the process, DO NOT press the **RUN/HOLD** button on the Partlow. Doing so will do nothing.

8.8 When a message on the touch screen said that the process is complete, press the big red **RESET** button on the system controller.

8.8.1 **Note:** The wait time for the chamber to ramp down to set point, may take many hours. Therefore, you can vent the chamber when the temperature drops to 120°C on your cooling step (abort your process). You can vent the chamber by setting the thumbwheel to 2 and press the black **START** button. Do not open the oven with temperature >120ºC. You can be seriously burned if the chamber is open when it is too hot.

8.8.2 **Note:** You may press the big red **RESET** button anytime to abort your process.

8.9 Unload your wafers. Insert spatula into the boat carrier bottom slot. Unload wafers with wafer carrier and put it on the cooling plate. Close the door. Unload the wafers, remove the spatula and store them back in the cubby next to the vacoven.

8.9.1 **Note:** Use the high temperature dedicated mitts (Hot Hands) to unload the anodized cassette when it is hot. Careful! You must have a good grip on the cassette when unloading it.

8.10 Leave the oven pumped down when not in use. Set the dial to 1 (pump down) and press **START** button.

8.11 If you want to skip a segment on the Partlow temperature program while your process is running, you may do so by pressing the **UP ARROW** button and the **PROF** button at the same time.

8.12 Chamber pressure has to be above 500 Torr to start a process.

9.0 ***Troubleshooting Guidelines***

9.1 **Alarm is sounding.**

9.1.1 Press **ABORT** to silence alarm.

9.2 Process is aborted with an HBA alarm.

9.2.1 A Heater Break Alarm indicates that the heater coils are not drawing current. This is a symptom that the coils are burnt out, or that a relay is burnt out, or that the PID temperature control setting have been altered. Report a Fault.

9.3 Process is aborted with an over temp alarm.

9.3.1 The process temperature has exceeded 462°C. The YES does not permit temperatures above 450°C to be entered. If you get this alarm, then it is probable that the PID settings have somehow changed and the oven temperature is over-shooting. Report a fault.

9.4 You cannot open the oven door even though no process is running.

9.4.1 The oven is not fully purged. Run the vent program by setting the thumbwheel to 2 and press **START**.

Note: Be careful when oven temperature is high. You can burn yourself.

9.5 Your process was aborted with an alarm while you were away and you want to know how far it went.

9.5.1 On the touch screen, press the **Alarms Panel** button. The alarms panel will display a list of all alarms and the times at which they occurred. If you noted when your process began, then the alarms panel will tell you when it aborted with an alarm.

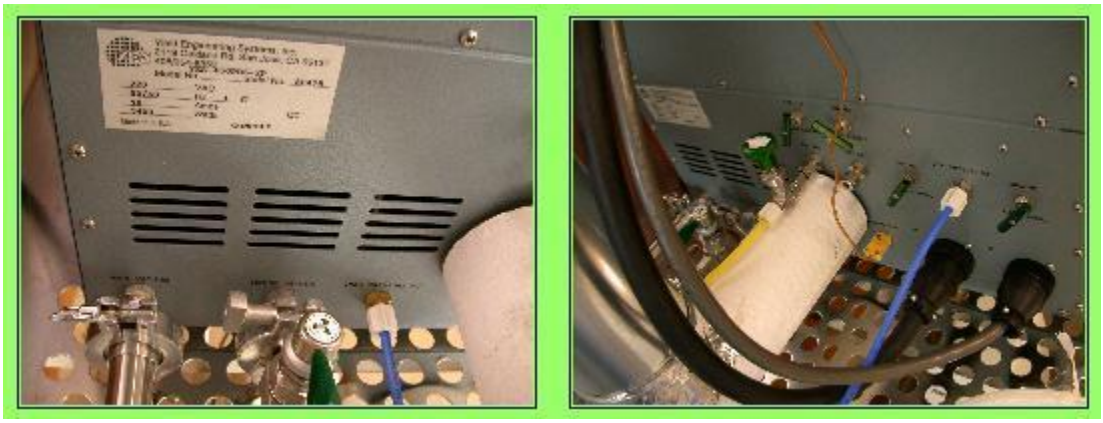
9.6 You attempt to run a Forming Gas Anneal process using N2 for your RAMP -UP gas and notice that no Forming Gas flows during your dwell step

9.6.1 Please contact Process Engineer 1

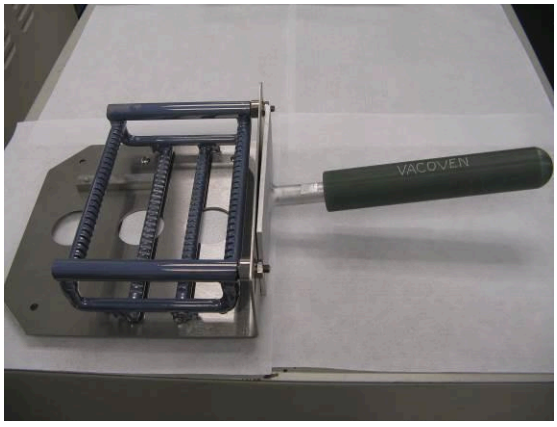
10.0 ***Study Guide***

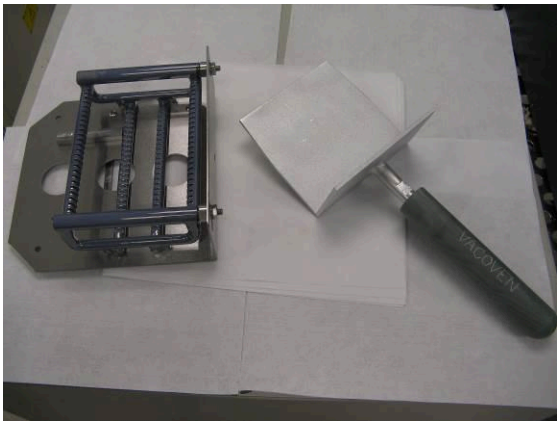
10.1 There is no online test for this tool

11.0 *Appendices, Figures & Schematics*

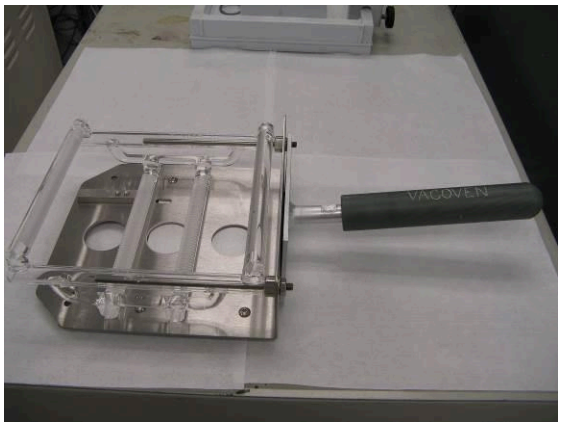


Main Vacuum & House Vacuum **Hot and Cold N2 Flow Control Valves**

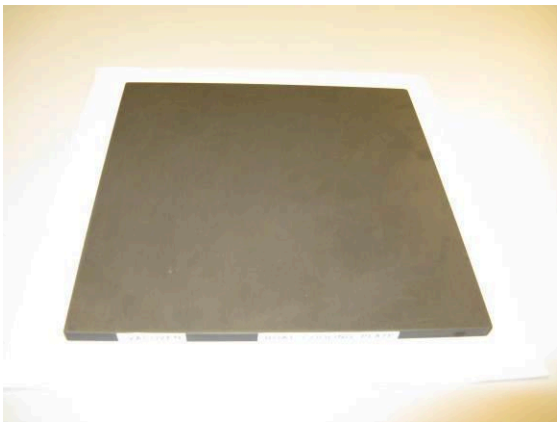




4” Wafer Boat/Carrier and Spatula **4” Wafer Boat/Carrier and Spatula**



6" Wafer Boat/Carrier and Spatula



Wafer Boat/Carrier Cooling Plate

Appendices

11.1 How To View a Program Without Running It

11.1.1 Select the desired program number on the Partlow by pressing **PROF** button.

11.1.2 Press **MODE** button.

11.1.3 Press **RUN/HOLD** button to index through the segments.

11.1.4 Press **SCROLL** (the circular arrow) button to see the temperature, time, and event output of each segment.

11.2 How To Program the Partlow Controller

11.2.1 NEVER TOUCH PROGRAMS 1-4. You can program 5-8. If you need help programming the Paltrow controller contact Process Engineer 1

11.2.2 The Partlow can store eight different temperature programs. Any given program can be joined to another program or repeated. For example, Program 1 can run Program 2 three times and then run Program 5 and then ramp up to 400°C, and dwell there for 2 hours, and end up by returning to the standby temperature.

11.2.3 Each program is divided into segments. There is a maximum of 16 segments in a program. A segment is composed of three specifications: a temperature, a time and an event output. Each segment tells the oven how to proceed from its previous state. The temperature (**Final SP** on the Partlow message display) may be a number between 0 and 450°C, but realize that the oven has no way of cooling below room temperature. The temperature can also be a dwell, denoted "----" on the Partlow. A dwell means to stay at the current temperature and it can be selected by pressing the up and down arrows at the same time.

11.2.4 It is recommended that all programs have a 5-minute dwell at the standby temperature to accommodate the time it takes for the dehydration loops (3 dehydration loops = ~ 4 minutes) for the first segment.

11.2.5 The **Time** specification indicates how long to attain this temperature step. The Partlow is currently set to display time as hh.mm format, hours and minutes. By scrolling below 00.00 minutes, you will also be able to select End program and various join options. (For example, J03 inserts Program 3 as the current segment..)

11.2.6 All programs must end with an End segment. If you select the End specification, the Final SP and Event outputs for the current segments are automatically set to End as well.

11.2.7 The **Event** output specification is a 4-digit binary number and should be set to 0000 for DWELL and RAMP UP steps. For the COOL DOWN step if you are using GAS 2 or GAS 3, but want to cool down with N2 program EVENT = 0001

11.2.8 Programs can only be entered when the Partlow is in Program Define Mode.

11.2.9 On the Partlow, press **PROF** button to select the number of the program you want to edit. Currently, Programs 1 to 5 are predefined programs. (Ask a process engineer which programs are available for editing: Programs 6 to 8 are currently available.)

11.2.10 Now press **SCROLL** (circular arrow) and **UP ARROW** buttons at the same time.

11.2.11 Next, use the **UP ARROW** key to select the unlock code number, which is 10.

11.2.12 Press **SCROLL** button. Now you are in the Program Define Mode and you can proceed to define the segments of your program.

11.2.13 To exit the Program Define Mode when finish programming, press the **MODE** button until the Partlow message display prompts **Exit?**

11.2.14 Then press **SCROLL** button.

Note: When specifying a temperature cool down segment, be aware that the YES oven only can cool down at a maximum rate of about three degrees per minute for temperatures above 200°C and less than 2 degrees per minute for temperatures under 200°C. If you want the oven to cool as fast as possible, specify 0°C as the temperature in the temperature ramp down segment.

11.3 Quasi-Manual Mode (Process Engineer Review required)

11.3.1 It is possible to approximate manual operation of the YES oven by changing the standby temperature to your desired process temperature.

11.3.2 To change the standby temperature, press **SCROLL** until the message display prompts **Ctr SP t**.

11.3.3 Then press the **UP/DOWN** arrow to change the standby temperature.

11.3.4 After you have reset the temperature, press **SCROLL** until the message display is **blank** to exit. **Be sure to change the standby temperature back to its original value when you are done!**

11.4 Standard Programs:

Program #1 - Standard 450°C Anneal Program

The idle temperature is set to 75°C.

Program Box	Segment Box	Message Display	Upper Display	Lower Display
1	1	Final SP	Current Temp	300 RAMP (ramp up)
1	1	Time	Current Temp	1.00 RAMP (1 hour)
1	1	Event	Current Temp	0000 Event Output
1	2	Final SP	Current Temp	---- DWELL
1	2	Time	Current Temp	0.30 DWELL
1	2	Event	Current Temp	0000 Event Output
1	3	Final SP	Current Temp	450 RAMP (ramp up)
1	3	Time	Current Temp	1.00 RAMP
1	3	Event	Current Temp	0000 Event Output
1	4	Final SP	Current Temp	---- DWELL
1	4	Time	Current Temp	0.30 DWELL
1	4	Event	Current Temp	0000 Event Output
1	5	Final SP	Current Temp	75 RAMP (ramp down)
1	5	Time	Current Temp	4.00 RAMP (4 hours)
1	5	Event	Current Temp	0001 Event Output #1 On
1	6	Final SP	Current Temp	---- DWELL
1	6	Time	Current Temp	0.01 DWELL
1	6	Event	Current Temp	0001 Event Output #1 Off
1	7	Final SP	Current Temp	END End of Program
1	7	Time	Current Temp	END End of Program
1	7	Event	Current Temp	END End of Program

When programming Segment 7, choose any Final SP temperature. Then set the Time to **End**.

This replaces the Final SP temperature with **End** and automatically sets the Event output to end.

Program #2 – 200°C Anneal for 30 minutes

Program Box	Segment Box	Message Display	Upper Display	Lower Display
2	1	Final SP	Current Temp	200 RAMP (ramp up)
2	1	Time	Current Temp	0.45 RAMP (45 min)
2	1	Event	Current Temp	0000 Event Output
2	2	Final SP	Current Temp	---- DWELL
2	2	Time	Current Temp	0.30 DWELL (30 min.)
2	2	Event	Current Temp	0000 Event Output
2	3	Final SP	Current Temp	75 RAMP (ramp down)
2	3	Time	Current Temp	0.01 RAMP
2	3	Event	Current Temp	0001 Event Output #1 On
2	4	Final SP	Current Temp	END End of Program
2	4	Time	Current Temp	END End of Program
2	4	Event	Current Temp	END End of Program

Program #3 – 300°C Anneal for 30 minutes

Program Box	Segment Box	Message Display	Upper Display	Lower Display
3	1	Final SP	Current Temp	300 RAMP (ramp up)
3	1	Time	Current Temp	1.00 RAMP (1 hour)
3	1	Event	Current Temp	0000 Event Output
3	2	Final SP	Current Temp	---- DWELL
3	2	Time	Current Temp	0.30 DWELL
3	2	Event	Current Temp	0000 Event Output
3	3	Final SP	Current Temp	75 RAMP (ramp down)
3	3	Time	Current Temp	0.01 RAMP
3	3	Event	Current Temp	0001 Event Output #1 On
3	4	Final SP	Current Temp	END End of Program
3	4	Time	Current Temp	END End of Program
3	4	Event	Current Temp	END End of Program

Program #4 – 400°C Anneal for 30 minutes.

Program Box	Segment Box	Message Display	Upper Display	Lower Display
4	1	Final SP	Current Temp	400 RAMP (ramp up)
4	1	Time	Current Temp	1.50 RAMP (1.5 hour)
4	1	Event	Current Temp	0000 Event Output
4	2	Final SP	Current Temp	---- DWELL
4	2	Time	Current Temp	0.30 DWELL
4	2	Event	Current Temp	0000 Event Output
4	3	Final SP	Current Temp	75 RAMP (ramp down)
4	3	Time	Current Temp	0.01 RAMP
4	3	Event	Current Temp	0001 Event Output #1 On
4	4	Final SP	Current Temp	END End of Program
4	4	Time	Current Temp	END End of Program
4	4	Event	Current Temp	END End of Program

Old Program #5 (not active) – 350°C Anneal for 30 minutes

5	1	Final SP	Current Temp	30 RAMP (ramp up)
5	1	Time	Current Temp	1.00 RAMP (1 hour)
5	1	Event	Current Temp	0000 Event Output
5	2	Final SP	Current Temp	---- DWELL
5	2	Time	Current Temp	1.00 DWELL
5	2	Event	Current Temp	0000 Event Output
5	3	Final SP	Current Temp	200 RAMP (ramp up)
5	3	Time	Current Temp	0.40 RAMP
5	3	Event	Current Temp	0000 Event Output
5	4	Final SP	Current Temp	---- DWELL
5	4	Time	Current Temp	1.00 DWELL
5	4	Event	Current Temp	0000 Event Output
5	5	Final SP	Current Temp	350 RAMP (ramp up)
5	5	Time	Current Temp	0.20 RAMP (20 min.)
5	5	Event	Current Temp	0001 Event Output
5	6	Final SP	Current Temp	---- DWELL
5	6	Time	Current Temp	1.00 DWELL
5	6	Event	Current Temp	0000 Event Output
5	7	Final SP	Current Temp	30 DWELL
5	7	Time	Current Temp	0.01 DWELL
5	7	Event	Current Temp	0001 Event Output #1 On
5	8	Final SP	Current Temp	END End of Program
5	8	Time	Current Temp	END End of Program
5	8	Event	Current Temp	END End of Program