

# Instruction Manual

## Supplementary Instruction Manual

### For the Ramp/Soak option of SYL-4342P and SYL-4352P Programmable Controller

Version 4.3

This is a supplementary manual for the SYL-4XXXP controller. It is only for operating the programmable steps (ramp and soak steps) functions. The main manual for the SYL-4XXXP is the same as the SYL-4XXX. It covers all the regular set up and operation instructions.

The SYL-4XXXP series programmable controllers with the ramp/soak option (including SYL-4342P and SYL-4352P) are designed for applications where it is desirable to have the set point automatically adjust itself over time.

#### 1. Features

- 30 steps of program control for ramping and soaking process.
- High flexibility in program and operation. It has programmable/maneuverable commands such as jump (for loops), run, hold and stop. The program can even be modified while it is running.
- The program can also control the two relays that are used for alarms. This feature can be used to notify the operator of the stage of the operation, or to signal other equipment.
- The safety start and ready functions may allow the program to run more efficiently. 6 power-off/power-on event handling (see 3.10) modes can be selected. This can prevent the program control from being adversely affected by unexpected power interruptions.

#### 2. Terms and Functions

**Program StEP:** The value of the program StEP can range from 1 to 30. The current StEP is the program StEP being executed.

**StEP temperature, CXX:** The StEP temperature is the set temperature at the beginning of the step XX (where XX can be any value from 01 to 30).

**StEP time, tXX:** The StEP time is the ramping time from the current step temperature to the next step temperature. The unit is in minutes and the available value range is from 1 to 9999.

**Running time:** The running time is the time that the current StEP has been running. When the running time reaches the StEP time, the program will jump to the next StEP automatically.

**Jump:** The program can jump to any other steps in the range of 1 to 30 automatically as you programmed in the program StEP. It can also be used to perform cycle control. If StEP number is modified, the program will also jump. Furthermore if the program StEP reaches and finishes the 30<sup>th</sup> StEP, the program will jump back to the first StEP and run automatically.

**Run:** When the program is in the "running" status, the timer counts down, and the set point value changes according to the preset ramp curve.

**Hold:** When the program is in the "hold" status, the temperature is still controlled, but the timer is paused so the current set point remains.

**Stop:** When the stop operation is activated - the program, timer, and output control will stop, and the running time and event output switch will reset. If the "run" operation is activated while the instrument is in the "stop" status, the program will start up and run from the StEP 1.

**Power interrupt:** It means the power has turned off or an unexpected power failure has occurred during running status. 6 selectable handling modes are available for the user.

**Event output:** Event output can be programmed in to the controller. It can trigger two alarm relays to make external equipment operate with interlock.

**Safety start:** If the difference between the PV and SV is larger than the deviation alarm setting at the beginning of a step (or when powered up), the controller will adjust the PV until the deviation alarm is turned off before the timer starts. It is useful when the user does not want to control the ramp speed and system needs to reach the set temperature as soon as possible. Please see 3.2 for example.

#### 3. Programming

##### 3.1 Program Setup

Press the A/M key to bring the instrument into the program setup mode; the instrument will display the temperature set point of the current StEP (indicated by "C" in the upper display followed by the StEP number). Use the < key to choose which digit to edit (indicated by the flashing decimal point). After adjusting the temperature set point (-1999 to +9999), press the SET key once again, and the current StEP's ramping time will be displayed ("t" in the upper display). In each program StEP, the temperature and the time is displayed in turn. Hold down the < key and press V to go back to the previous parameter. Hold < and press SET to exit program setup mode. Modifying program steps while a program is running is permitted. See section 4 for a programming example.

Note: the above operation is inhibited if the program setup function is locked (refer to 3.11 for the introduction of the Lock parameter).

##### 3.2 Program Ramp

To program a ramp, you need to set the start temperature CXX, the end temperature CXX+1, and the time duration tXX. For example, at step 3, if you want the controller to take 60 minutes to ramp up from 200 to 300 degrees, set C03=200, C04=300, t03=60.

Note: Unless the deviation alarms are set to a narrow range, the ramping time decides when the program is going to the next step. Once the ramping time is finished the current step, the controller will execute the next step regardless if the temperature reaches the target temperature. Therefore, the ramp speed should be always slower than the maximum speed that the oven can offer at the full power. In other words, the ramping time should be longer than the minimum time needed for oven to jump from C03 to C04 at full power. If the ramping time is shorter than that, the time programmed for the next step will not be fulfilled. When program a temperature ramps down, you need to consider the speed of natural cooling (or forced air cooling) for the same reason.

If the maximum speed of the system is unknown or varies with environmental conditions, users should use the "safety start" function to ensure that the temperature and time during ramping and soaking are kept within a reasonable range required by the process. This is done by setting the deviation alarm close to the SV. At the beginning of a step, the timer will not start until PV is larger than SV-Hy-2+Hy and smaller than SV+Hy-1-Hy. e. g. Set Hy-1=30, Hy-2=20, Hy=5 and SV=100. At the beginning of the step, if the temperature is below 85 (SV-Hy-2+Hy=85) degrees, or above 125 (SV+Hy-1-Hy=125) degrees, the controller will stop the timer and try to control the temperature to be above 85 degrees or below 125 degrees before continuing. It will control the temperature to reach this range as soon as it can. Please note that the Hy value should be smaller than both Hy-1 and Hy-2. Otherwise the controller will not start the next steps.

##### 3.3 Program Soak

The soak can be considered as a special case of ramping. It is a ramp with a zero degree slope. To program a soak, you need to set the start and the end temperature to be the same (CXX=CXX+1), e.g. At step 3, if you want the controller to soak the parts at 200 degrees for 60 minutes, set C03=C04=300, t03=60.

Note: The StEP time is not how long the controller will stay at the set temperature for the current step. It is how long the controller will take from the current step temperature set point to the next step temperature set point. These two concepts are very different.

##### 3.4 Program Hold

When the program reaches a StEP where the StEP time is set to zero, or when a jumping StEP transitions to another jumping StEP, the program will be set to "hold" status. The A-M LED blinks in this mode. You can also manually activate hold status by pressing the V key for roughly 2 seconds until "HoLd" appears in the lower display window.

**3.5 Program Stop**

When the program reaches a StEP where the StEP time is set to -121, the controller will stop running. The StEP number is reset to 1, the event output is cleared, and the control output is turned off. You can also manually execute the stop operation by pressing and holding the  $\Lambda$  key for roughly 2 seconds until the lower display window displays "StoP". The A-M LED is off in this mode.

**3.6 Run Program**

In order to continue the program when the controller is in "hold" mode (or restart it from "stop" mode), press the V key for about 2 seconds until the lower window displays "run". When a program is running, the A-M indicator LED is on.

**3.7 StEP Time/Command Parameter**

When tXX is between 1 and 9999 (min), it is used to set the ramp and soak time. When it is set to zero or a negative number, it is used for executing other commands.

tXX=0 The instrument is put in hold mode on StEP number XX until manually released by the operator.

tXX=-1 to -240 represents an operation command such as run, hold, stop, jump and event output. The number is calculated according to the equation  $tXX = -(A*30+B)$ .

"B" is the number (ranging from 1 to 30) of the next step for the program to jump to and "A" is the event that is triggered:

A=0 no effect (for jump function only)

A=1 switch on AL2

A=2 switch on AL1

A=3 switch on AL1 and AL2

A=4 Stop the instrument (B must be set to 1 when A=4)

A=5 switch off AL2

A=6 switch off AL1

A=7 switch off AL1 and AL2

**Examples:**

- Jump from StEP4 to StEP5 and switch on AL2.

Time setup is:  $t04 = -(1 \times 30 + 5) = -35$

- Jump from StEP6 to StEP1 and switch off AL2.

Time setup is:  $t06 = -(5 \times 30 + 1) = -151$

- Stop program at StEP8

Time setup is:  $t08 = -(4 \times 30 + 1) = -121$

The controller does not let a jump command jump to itself (for example:  $t06 = -6$ ) because the Hold status would never be released.

**3.8 Displaying and modifying the running StEP number (StEP) of the program**

Sometimes it is convenient to jump directly to a particular StEP and execute from there. If the program is still in the middle of the 4th StEP, and you wish to finish it in advance and execute the 5th StEP - the StEP modification feature will meet your need. The SYL series controller can start the program from any one of its 30 steps.

Press the SET key (briefly) to display the StEP number. Press the  $\Lambda$ , V keys to change it. The StEP number increases or decreases automatically as the program executes. If the StEP number is manually changed, the running time will be cleared to 0 and the program will begin with the new StEP.

If the StEP number is not changed, pressing the SET key will not affect the operation of the program.

**3.9 Multiple Curves**

The flexible programming format of the SYL-4XXXp can be used to store and recall multiple programmed curves. If a temperature curve doesn't require all 30 steps, the unused steps can be used to store another program. Several different curves can be stored and executed individually, as long as there are not more than 30 steps total (including necessary controls steps). For example, when a process curve only needs nine program steps, it is possible to store three such process curves in the instrument. Simply change the StEP number to initiate a different curve. Suppose 8 steps represent three groups of process parameters. They are separately arranged on StEP2-StEP9, StEP10-StEP17, StEP18-StEP25. The step time of step 1 can be set as follows to choose the desired program:

T01=-2 Execute the program of curve 1 (StEP2-StEP9)

T01=-10 Execute the program of curve 2 (StEP10-StEP17)

T01=-18 Execute the program of curve 3 (StEP18-StEP25)

You can also choose the curves by manually setting the value of StEP before the program starts. For example, if curve 2 is needed in the current process, then set the value of StEP to 10.

**3.10 Control Mode Parameter A-M**

The function of the A-M parameter is defined differently in the SYL-4XXXp than it is for the controller without the ramp/soak option. Its operation is determined according to the equation

$$A-M = AX1+BX4$$

Where "A" is used to select one of 3 power outage/startup event handling modes, and "B" is used to select one of two hold modes.

**Power Outage/Startup Modes:**

**A=0:** When the instrument is turned on, the program will simultaneously jump to 29th program segment and clear event output status. This mode is suitable for applications in which power failure is not allowed at any time. The user may do error handling in segment 29 such as switching on the event output to trigger an alarm.

**A=1:** If there is no deviation alarm at power up, the program will continue running from the original break point and the event output state remains. Otherwise, the program will jump to the 29th segment and clear event output status.

**A=2:** After power is turned on, it will continue the program from the original break point, and the event output state will remain. This mode is suitable for the applications in which power failure does not affect production. (default setting)

**Hold Mode definition:**

**B=0:** When the controller is put into hold mode, the PV is maintained at the current SV. (Default setting)

**B=1:** the output of the controller is at OutL when it is on hold.

The default setting of the controller is A=2, B=0, A-M=2.

**3.11 Privilege for parameter set Lock**

For SYL series controllers with the ramp/soak option, the Lock has slightly different functions.

The table 1 shows the privilege of each lock code.

Table 1. Lock parameter

Lock value	EP1-8 Adjustment	Program Adjustment	StEP Selection when running
0	Yes	Yes	Yes
1	Yes	No	Yes
2	Yes	No	No
3 and up	No	No	No
808(Default setting)	Yes	Yes	Yes

**4. Programming Example**

Programs in the SYL-4XXXp series controller have a uniform format of temperature-time-temperature. The temperature set point of the current step will linearly change to the set point of the next step over the time interval of the two steps. The first temperature set point should always be the ambient temperature at which the process starts to ramp up. **DO NOT** set the first temperature set point to the target temperature (see example 1 below). The time units are in minutes. Negative values of the time interval represent program commands.

**4.1 Example 1**

The following example holds the oven at 800 °C for 2 hours. In this example, it is assumed that the heater is able to heat the oven from 25 °C to 800 °C within 30 minutes. If the heater does not have this ability, the soak section can begin when the oven is below 800 °C after the 30 minutes ramping time is up.

Please note that the value of C is the beginning temperature of the step. e.g. C01 is always the temperature at the beginning of the step 1. Usually C01

should be the ambient temperature, and t01 is the time from step1 to step2.  
**STEP1: C01=25, t01=30** Start linear temperature heating up from 25 °C to 800 °C, over a time period of 30 minutes (25.8 °C /minute).  
**STEP2: C02=800, t02=120** Maintain 800 °C for 120 minutes.  
**STEP3: C03=800, t03=-121** Stop the program and let the oven cool down. The equation used to get the command number is  $-(30 * \text{Command\#} + \text{Next Step}) = -(30 * 4 + 1) = -121$ .  
 The temperature control block is shown below.

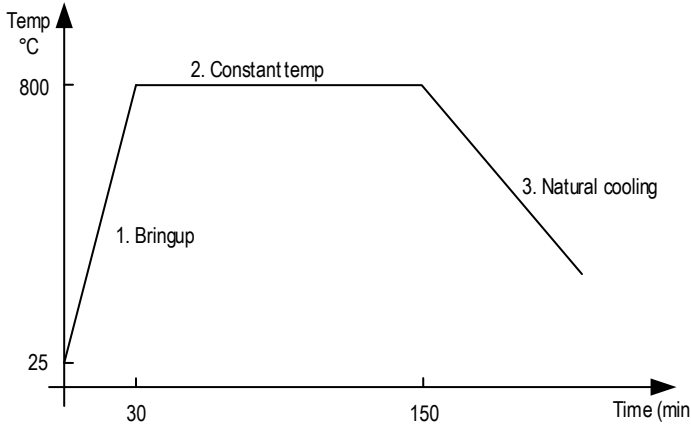


Figure 1. Holding oven at 800 °C for 2 hours

**4.2 Example 2**

The following example includes 6 steps: linear temperature heating, maintaining a constant temperature, linear temperature cooling, jump cycling, ready, hold and event output. In the following example, it is assumed that the deviation high alarm is set to 5 °C.

**STEP1: C01=100, t01=30** Start linear temperature heating up from 100 °C to 400 °C, over a time period of 30 minutes (10 °C /minute).

**STEP2: C02=400, t02=60** Maintain 400 °C for 60 minutes.

**STEP3: C03=400, t03=120** Reduce the temperature at a rate of  $|C04-C03|/t03 = 2$  °C /minute for 120 minutes. This will bring it down to 160 °C.

**STEP4: C04=160, t04=-65** Alarm 1 is triggered, and the program jumps to STEP5. The command number for turning alarm 1 on is "2". The equation used to get the command number is  $-(30 * \text{Command\#} + \text{Next Step}) = -(30 * 2 + 5) = -65$ .

**STEP5: C05=160, t05=0** A time value of zero puts the program in a Hold state. A run operation executed by the user is needed for the program to continue to STEP6.

**STEP6: C06=100, t06=-181** Alarm 1 is switched off (unless it is also being triggered by an alarm condition outside the program), and the program jumps to STEP1 to start from the beginning. The command for switching Alarm 1 off is "6", so  $t06 = -(30 * 6 + 1) = -181$ .

**STEP1: C01=100, t01=30** Since the temperature is still at 160 °C, the program will pause until the controller can bring the temperature within the alarm range of the new set point. Since the deviation high alarm is set to 5 °C, the program will resume (from the beginning) as soon as the temperature drops below 105 °C.

The temperature control block is shown below.

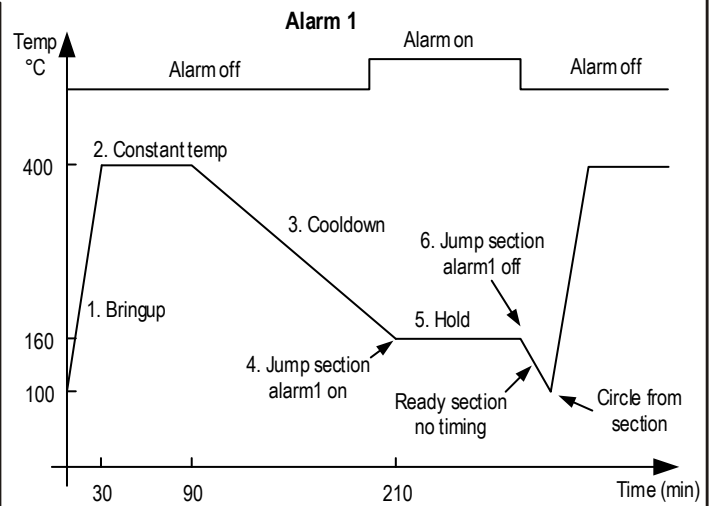


Figure 2. Ramp/Soak Example 2

**5. Quick list of the New Key Functions for the Ramp/Soak Model**

The following list contains a brief description of each key function for when the controller is in basic operation mode.

1) Mode Key (SET)

When pressed momentarily, PV display shows the current step that the program is processing. When pressed again, the PV display shows the set time length of the current step. The SV display shows how long the current step has run in minutes. Press again to have the display return to the basic display mode. The PV shows the process temperature and SV can either show the set temperature or the status of the controller (Stopped, Running, or on Hold).

Pressing and holding the mode key for two seconds will put the controller into parameter setting mode, just like the controllers without the ramp/soak option.

2) Data shift key (<)

Press this key to have the controller enter step setting mode in order to set the time, temperature and action of each step.

3) Decrement key V. Press and hold this key for two seconds to start the processing. The A-M LED will light up. Press and hold again to hold the processing. The A-M LED will flash.

4) Increment key ^: Press and hold this key for two seconds to stop the processing of the program. The A-M LED will turn off.

Table 2. Summary of New Key Functions

To start the processing	Press V for 2 seconds
To stop the processing	Press ^ for 2 seconds
To hold the processing	Press V for 2 seconds
Check current step	Press SET briefly
Check run time of current step	Press SET briefly twice
Go to step X	Press SET briefly, Then use V or ^ to go to the step.
To program the steps	Press < key to enter programming mode. Then, SET key to go to next step.

**6. Auto Tuning of the system to optimize the PID parameters.**

The Auto Tuning function of the controller should not be started at the very beginning of a process if the temperature of the system is at or near room temperature. It should be started when the system is heated up to near critical operating temperature. Users can manually start Auto Tuning by setting At=2, when the temperature is near that temperature.

## 7. Frequently asked questions

### 7.1 What is the difference between "Hold" and "Stop".

"Hold" does not stop heating. It holds the temperature at the current setting, (or at OutL, see 3.10 for details). "Stop" will stop heating. If you Hold the program (V key) and start Run (V key) again, it will start from the step that was put into hold. However, if you Stop the program (Λ key) and start Run (V key) again, it will start from step 1.

### 7.2 How do I run this controller as a regular controller without the ramp/soak function?

Here are two methods.

1) Program a very long step. If you didn't use up all the steps for programming, you can use one of the unused steps for that. For example, assuming step 10 and 11 are unused, set C10=100, C11=10 and t10=9999. This sets Step 10 to control the temperature at 100 degrees for 9,999 minutes. To begin the program, start Run (V key), press SET once to display StEP, use Λ to go to StEP 10. Press SET twice. The controller will run just like regular controller with PV displayed on top and SV in the bottom. You don't have to do this every time the controller powers up (assuming the A-M parameter has not changed from default). It will remain running StEP 10 until 9999 minutes (7 days) runs out, or until you reset it for another application.

2) Put the program on hold mode. This can be done either by manually pressing the Hold button at the desired temperature, or by programming a hold step (by setting tXX=0).

### 7.3 I just want to run the oven at 800 degrees for 120 minutes. When I set C01=800, t01=120, the controller SV first displays 800, then it starts dropping with time. Did I do something wrong?

This is the most common mistake first time users make. Since this is a ramp controller, not a step controller, the time t01 (or tXX) is not the time that controller will stay at C01 (or CXX), it is the ramping time that controller will take from temperature C01 to C02. To hold the temperature constant for 120 minutes, you need to set two steps at the same temperature, or a 0 degree ramp (C02=C03=800 in this case). Then, set the ramping time for 120 minutes. Please see example 1.

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