CYL 100 Temperature Specifications

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Temperature Range: -20 °C to + 110 °C

The TC 1 Temperature Controller can set temperatures between -40 °C and 110 °C. Under normal conditions, circulating room temperature (~22 ^{o}C) water through the Peltier heat exchanger, the **CYL 100** will achieve temperatures in the range of -20 °C to 110 °C. Somewhat lower temperatures (-25 ^{o}C) can be obtained using ice water. Additional insulation and even colder coolant (circulating chiller) will be needed to achieve the lowest temperatures.

Note that a dry purge gas must be used for work below the dew point temperature to prevent condensation on the cuvette.

Temperature Precision: better than ± 0.01 °C

Temperature precision is a measure of how well the temperature controller keeps the cuvette holder at constant temperature. For the **CYL 100** the average deviation for temperatures reported by the RTD thermometer with the probe in the sample holder probe hole are included in Table 1 for set temperatures between -20 ^{o}C and +100 ^{o}C. The **CYL 100** sample holder did not have a cuvette in it during these measurements.

Table 1. Average deviation (for 30 points) of the reported RTD temperature from the set (target) temperature.

Set temperature	-20	0	20	40	60	80	100
Average deviation	0.003	0.008	0.006	0.003	0.005	0.005	0.06

Temperature Accuracy: within ±0.30 °C

Temperature Accuracy is a measure of how well the temperature of the sample holder compares to the temperature set by the TC 1 Temperature Controller.

Figure 1 shows deviations for 55 measured temperatures for set temperatures between -20 ^{o}C and +110 ^{o}C. All of the points are within **±**0.30 ^{o}C of the set temperatures. For set temperatures below 100 °C all the points are within ±0.2 °C of the set temperatures. The discrepancy may be related to the number of decimal places given by the RTD thermometer (two for Set Temperatures < 100 °C and one for Set Temperatures >= 100 °C).

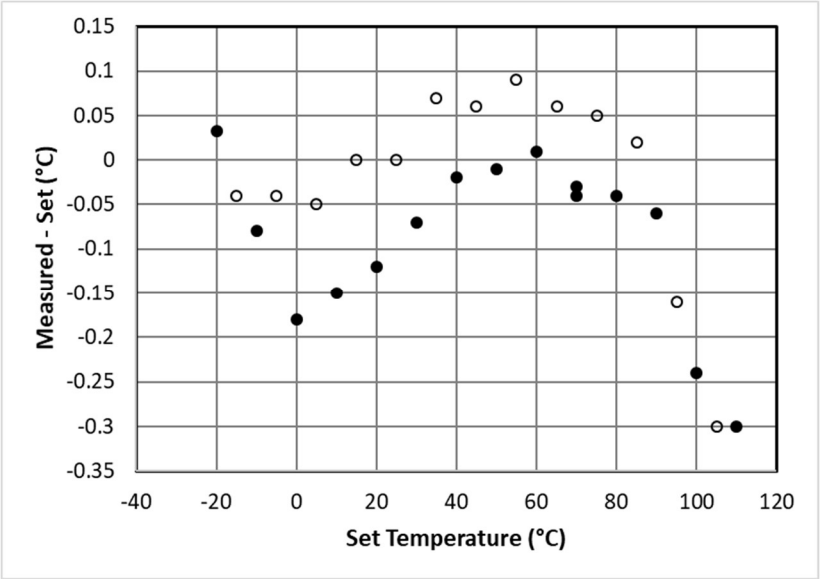

Figure 1. A NIST-traceable RTD thermometer (probe accuracy ±0.03 °C from -99.9 °C to +99.9 °C) was inserted in the probe hole of the cuvette holder and the temperature deviations (y axis) compared to the temperature set by the *TC 1 Temperature C*ontroller (x axis). Data points shown as open circles are results obtained with the temperature decreasing; the filled circles indicate results obtained with the temperature increasing.

Temperature Reproducibility: better than ± 0.07 °C

Temperature reproducibility is a measure of the ability of the temperature to return to an original value for any given set temperature (See Figure 1.). It accounts for differences found mainly depending on the direction of temperature change. In Figure 1, the set temperature with the worst reproducibility is 0 ^{o}C with a total range of -0.18 to -0.05 ^{o}C. The temperature reproducibility reported is half of this range.

Example of Temperature Performance

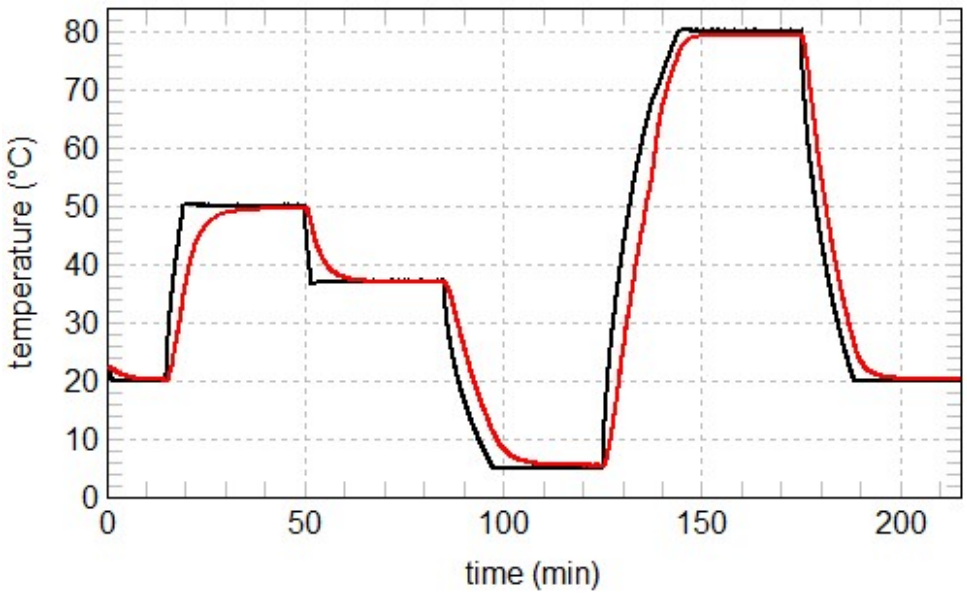

Figure 2. The **CYL 100** cuvette, 10 cm long and 2 cm inside diameter, filled with room temperature water was placed in the sample holder. The sample was stirred by two 7x2 mm stir bars directly under the fill ports 1 cm from each end of the cuvette. The stirring rate was 1000 rpm.*

The target temperature was set to 20 °C and temperature control turned on at time = 0 min. The target temperature was then set to 50, 37, 5, 80 and 20 °C. The black trace is the temperature of the sample holder. The red trace is the temperature of the sample as measured with a Series 500 thermistor probe connected at the back of the TC 1 controller with the thermistor element near the center of cuvette.

*The stirring method described was tested by quickly adding concentrated blue food coloring at one end of the cuvette; as judged visually, the distribution of dye was uniform within 2 minutes.

Temperature Equilibration

The data from Figure 2 were analyzed to give the results in Table 2.

Table 2. The data from Figure 2 were analyzed to give the time required for temperature changes. Three times are given for the cell holder temperature and two for the sample temperature measured by the thermistor:

1. The time required to get within 0.5 °C of the final temperature reading;
2. The time after which the temperature remains within ±0.2 °C from the final reading;
3. The time the controller begins to indicate by an LED that the holder temperature has remained stable (within ±0.05 °C of the set temperature for 1 minute).

Temperature change (°C)	5 to 80		80 to 20		37 to 5		20 to 50	
Final sample temperature (°C)		79.2		20.1		5.4		49.4
1. Within 0.5 °C (min)	20.0	23	13.0	21	11.7	22	4.8	31
2. Stays within ± 0.2 °C (min)	20.0	24	14.0	25	13.2	25	5.8	35
3. Lock on indicator light (min)	20		15		14		6	

Temperature Uniformity

Table 3. The 10 x 2 cm cuvette, filled with water, was placed in the CYL 100 holder with the TC 1 controlling the holder temperature at 50 °C. The sample was stirred by two 7x2 mm stir bars directly under the fill ports 1 cm from each end of the cuvette. The stirring rate was 1000 rpm.

The thermistor was positioned at the indicated distance from the left window and at least 0.5 cm from the cylinder wall. The thermistor probe temperatures are an average of 20 values after the reading was allowed to stabilize

.

Approximate Distance of the Probe Tip from the Left Window	**Thermistor Probe Temperature**
0.1 cm	49.3
1 cm*	49.3
2.5 cm	49.1
5 cm	49.6
7.5 cm	49.4
9 cm*	49.4
9.9 cm	49.4

*Probe tip was above the stir bar.