

857 Pump Tubing and Flow Rate Calibration

Introduction

The actual flow of a peristaltic pump depends on many factors that can not necessarily be accounted for during factory test and calibration. These factors include solution viscosity, fluid flow resistance due to the flow cell, fittings and tubing, as well as tubing properties such type, stiffness and operating life. Therefore, where feasible, 857 users should calibrate the pump tubing under conditions the match as closely as possible the actual or anticipated flow cell operating conditions. This document provides guidance in the tubing calibration procedure.

What you will need

- 857 Redox Flow Cell Test System and *FlowCell*[™] software
- Graduated cylinder or precision analytical scale
- Test solution (anolyte and catholyte) or other suitable fluid
- Flow cell hardware (optional)
- Pump heads installed on 857 pumps through flow bench front panel
- Pump tubing – Tubing Sizes 13, 14, 16, 15
- Masterflex[®] L/S Series Peristaltic Pump System Manual
 - Available on the CD in the Pump Quick Start Guide included with the 857 documentation
 - Contact Scribner for an electronic copy of the Pump Manual if the CD is misplaced

Procedure

1. Install and configure 857 as described in the 857 manual and installation instructions.
2. Power on the 857 Controller. The pumps should be ON.
3. Enter LOCAL mode through pump control panel.
 - a. Press ENTER key, use arrows to navigate to “Local” mode. Press ENTER key.
 - b. Enter Remote Control section, under START-STOP change to OFF.

NOTE: Access the pump control panel by reaching around behind the front panel plate of the 857 flow bench. ***Do not remove the pump drive itself from the flow bench.***

4. Follow the Tubing Calibration procedure described in the Appendix or Section 3, pages 3.4-3.5 of the Masterflex[®] L/S Series Peristaltic Pump System Manual.
 - a. Select appropriate tube size and set pump flow direction to clockwise (CW ↻).
 - b. Ignore entering flow rate.
 - c. On completion of the Tubing Calibration procedure, the Max Flow (5 V Input and Output Voltage) and Mid Flow (2.5 V Input and Output Voltage) settings in the Remote Control menu will automatically be updated to reflect the calibration results.

5. Enter the Remote Control menu and note the Max Flow Rate (mL/min); that is, the Max: 5 V Flow Rate. The Max Flow Rate (mL/min) is required to update the pump scaling parameters in the *FlowCell.ini* configuration file (see step **Error! Reference source not found.**).
 - a. Local: Start Stop - ON
 - b. Current Input: skip
 - c. Current Output: skip
 - d. Voltage Input:

Min: 0.0V	Flow: 0 (default)
Max: 5.0V	Flow: <i>automatically updated from step 4. Note value.</i>
Mid: 2.5V	Flow: <i>automatically updated from step 4</i>
 - e. Exit.
 - f. Voltage Output:

Min: 0.0V	Flow: 0 (default)
Max: 5.0V	Flow: <i>automatically updated from step 4</i>
Mid: 2.5V	Flow: <i>automatically updated from step 4</i>
 - g. Exit.
 - h. Turn START-STOP to ON.
 - i. Re-enter Remote Control menu, select Voltage Input, scroll through settings, select Exit.
 - j. Exit to leave menu.
6. Update the pump scaling factors in the *FlowCell* software (requires version 1.2e or later).
 - i. Update *FlowCell* if necessary at www.scribner.com
 - ii. Select File | Instrument Configuration and enter to the instrument serial number.
 - iii. In the Flow Configuration menu, enter the Full Flow of the Controller for the negative and positive side pumps - Figure 1.
 - iv. Select OK and save the settings.
 - v. Exit and re-start *FlowCell*.

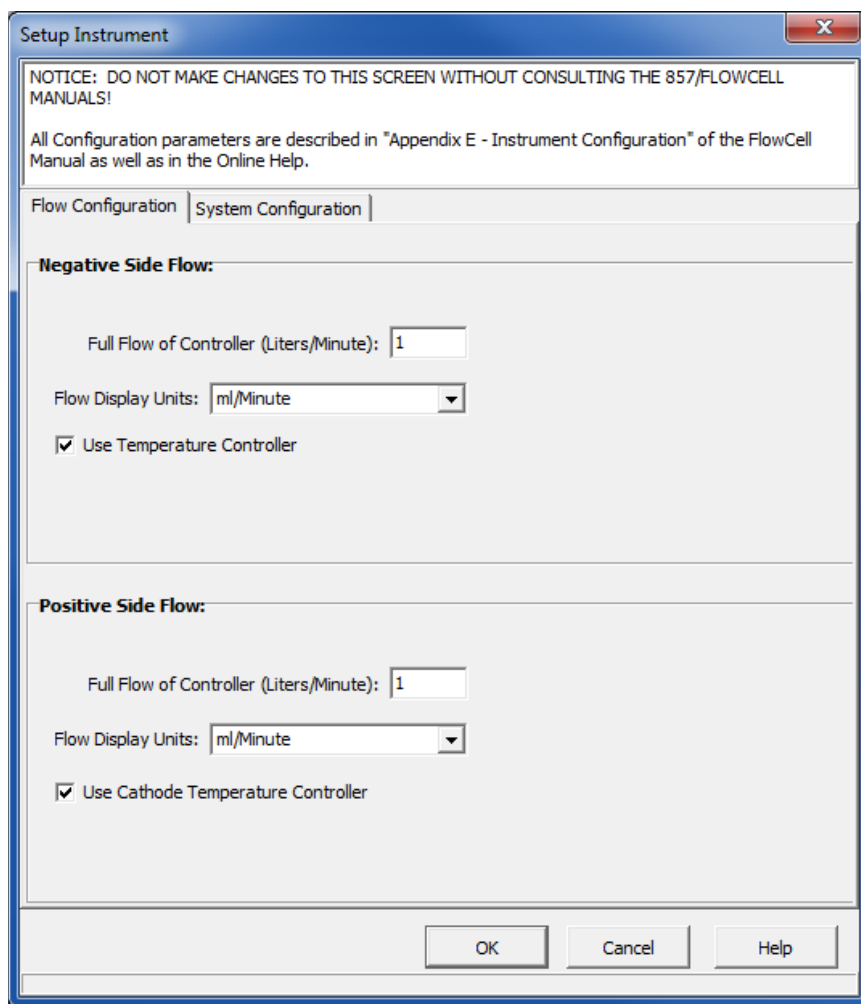


Figure 1 – Flow Configuration menu in *FlowCell* software.

7. Nominal flow rate settings for common tubing sizes are shown in Table 1.

Table 1. Nominal Flow Rate Parameters for Standard Tubing Sizes

		<i>Tubing Size</i>			
		<i>13</i>	<i>14</i>	<i>16</i>	<i>15/25</i>
Nominal Volume per revolution, mL		0.06	0.22	0.8	1.67
Voltage Output	Min: 0.0V	0	0	0	0
	Max: 5.0V	36	130	480	1000
	Min: 2.5V	18	65.0	240	500
Voltage Input	Min: 0.0V	0	0	0	0
	Max: 5.0V	36	130	480	1000
	Min: 2.5V	18	65.0	240	500
<i>FlowCell.ini</i> Flow Rate Scale Settings	mL/min / V	7.2	26	96	200

8. Start *FlowCell* software and verify the flow rate control/ setting.



- a. Zero reading on analytical scale (or note volume in graduated cylinder) prior to running experiment.
- b. In the Setup Flow menu, set both pump flows to 0.
- c. On Main Screen, select “New” and “Change Fuel” to create a flow experiment.
 - i. Select “Fixed” and set the flow rate for one pump, leaving the flow rate for the other pump zero.
- d. On Main Screen, select “New” and “Open Circuit” to set the time interval for experiment.
 - i. Select the time interval (min) and flow rate (mL/min) such that the volume of solution pumped can be accurately determined.
- e. Select Apply Flow and Apply Pstat (both buttons will be red).
- f. Select Run All.
- g. Monitor the reported flow rate in *FlowCell* and on the pump’s panel display.
- h. At the end of the experiment sequence, when the pump stops, determine the actual flow rate based on the measured volume or (mass and solution density is using a scale). The measured flow rates should be consistent with setpoint and reported value in *FlowCell* software.

Appendix – Pump Calibration Instructions

Section 3 Operation

Tubing Calibration

1. Mount Pump Head to drive.
2. Insert appropriate tubing into Pump Head.
3. Insert tube inlet into supply fluid.
4. Insert tube outlet into desired container. Container should be a graduated container or a container placed on a scale may be used for increased accuracy.

If using a scale, an acceptable weight to volume conversion for water is 1 gram = 1 mL.
5. Turn on drive using power switch located on the rear of the drive.
6. Go to the Main Menu or Mode Setup Menu by selecting the SETUP icon  and pressing the ENTER key. Use the UP and DOWN keys to highlight TUBING CAL in the Main or Setup Menu and press the ENTER key.
7. Set the drive for the desired flow direction, tube size, and flow rate. Note that these settings are retained and transferred to other mode screens when entering or leaving the TUBING CAL screen.
 - The flow direction is set using the directional keypad to highlight the directional arrow. Pressing ENTER will toggle arrow between CW and CCW.
 - The tube size is set using the directional keypad to highlight the tube size field. Press ENTER and use the UP/DOWN keys to select the tube size. Press ENTER to SAVE the selection and return to TUBING CAL screen.
 - The estimated flow rate is set using the directional keypad to highlight the flow rate field. Press ENTER and use the LEFT/RIGHT keys to select the digit to be changed. Use the UP/DOWN keys to adjust the flow rate value. Press ENTER to SAVE the setting and EXIT field using arrow keys. The drive will adjust this flow rate after calibration is complete.
 - Note that the calibration volume is fixed and cannot be changed.
8. Press and hold the prime key  on the drive console to prime the pump. Priming will stop when key is released.
9. Place a measuring container at the pump outlet. Highlight the START field and press the ENTER key. The drive will run based on the default volume at the estimated flow rate selected.

Tubing Calibration (continued)

10. Upon completion of the calibration run period, the CAL VOLUME field will be highlighted. Press the ENTER key and adjust the CAL VOLUME to the measured quantity. Use the LEFT/RIGHT keys to select digit to be changed, use the UP/DOWN keys to adjust the value, and press ENTER to SAVE setting and EXIT the field.

A lower case “c” should now be displayed when the calibrated tubing size is selected. The volume units will depend on the flow rate units. The flow rate unit mL/min will result in a volume unit of mL; oz/min will result in a volume unit of oz.

Tubing Calibration Notes

- If the drive is stopped during calibration, empty the container and re-start the procedure.
- Calibration time at maximum allowable flow rate (default max flow rate) is 5-10 seconds and at minimum allowable flow rate (approximately 4% of the maximum flow rate) is 4 minutes. Select the CUSTOM tube size for other tubing sizes or lower flow rates.
- Minimum and maximum flow rates will change after a tubing calibration due to a re-calculation of the vol/rev.
- Optimum results are best obtained after tubing has been broken in by running in pump for at least 10 minutes. Steps 8-10 can be repeated as necessary to optimize the accuracy of the tubing cal.

CAL RUN TIME FORMULA

$$60 / (\text{flow rate [mL/min]} / \text{cal volume [mL]}) = \text{cal run time (seconds)}$$

INVALID CAL RUN TIME EXAMPLE

- tube size 13 flow rate range is 0.006 mL/min – 36.0 mL/min
- at flow rate of 1 mL/min, cal run time calculation is as follows:
 $60 / (1 \text{ mL/min} / 6 \text{ mL}) = 360 \text{ seconds}$
 360 seconds exceed the max run time of 4 minutes (240 seconds)