



Start-up: “Volume Flow Metering into a Bioreactor or Fermentor”

Equipment: You will need the following items to get started:

SciLog P/N	Description	Quantity
100-138MASS	ChemTec, CP-120 w/ 1081 Tandem Peristaltic Head, 160rpm Motor	1 pc
400-116	Silicone Tubing, Platinum Cured, #16	25 ft (1 pkg)
080-095A	Printer Kit, includes Printer, Cable, 6 rolls Paper	1 kit
	Appropriate Media Reservoir	1 pc
	Appropriate BioReactor or Fermentor	1 pc

Hardware Setup:

1. Unpack all the components, visually identify and inspect for damage.
2. At the Reaction bench, place the Media reservoir to the far left. Moving to the right on the bench, place the ChemTec, and then the Bioreactor or Fermentor. Leave some space between these items so you can hook up cables and tubing.
3. Connect the printer interface cable between the rear of the printer and the “Printer” connector on the rear of the ChemTec. This cable does not have its ends labeled, as it is the same on both ends and may be reversed. Place the printer in a convenient location on your benchtop.
4. Plug in and power-up all the equipment.
5. Cut approx. 6-8 ft. of the #16 tubing and connect it to the Media reservoir. Route the tubing from the reservoir to the ChemTec, open the head by rotating the lever 180 degrees counter-clockwise, and place the tubing over the upper set of rollers. Confirm that the tubing is under the centering springs and close the head by rotating the lever back to its original position. Connect the remaining end to the Bioreactor or Fermentor. This completes the hardware and tubing configuration.

Calibration:

The Volume Flow mode requires careful volumetric calibration in order to achieve high accuracy performance. This calibration should be performed at a flow rate close to that which you intend to implement. Flow rate ranges are dependant on motor rpm, pump head, and tubing size choices. For the purposes of this example, we have a 160rpm motor, a Tandem 1081 peristaltic pump head, and #16 tubing. This yields a flow range of 6-129ml/min. Since the program listed below starts at 10ml/min and ramps up to 60ml/min, performing a calibration at 50% of motor speed, or approx 60 ml/min and a calibration volume of 600ml would be appropriate.

Press the “EXIT” button several times to reach the top of the menu. This display is seen:

Mode Selct		MASS FLOW
Up	Down	Select
A	B	C

Press "A" or "B" to scroll until the following appears:

Mode Selct		CALIBRATE
Up	Down	Select
A	B	C

Press "C" to Select, and this screen is displayed:

- CAL -	UNCALIBRATED	
Exec	Edit	Prime
A	B	C

Press "B" to Edit, and you can scroll through the following parameters for the calibration:

CLEAR CAL: Clears the existing calibration before entering a new one. Press "C" to Select, and "A" for Yes.

CAL VOLUME: Enter the calibration volume/weight. A volume equal to 10 times the pump rate is suggested as a minimum. (60ml/m x 10 = 600ml) Press "C" to Select, then "A" and "B" to Increase or Decrease the amount, and "C" to Select it.

CAL UNITS: Select one of the following units: L/m, ml/m, ul/m, as well as grams/m and milligrams/m. If you intend to calibrate in terms of gm/m or mg/m, be sure to use a balance with a 0.01gm resolution. This choice controls the units displayed on both the pump and the print out.

PUMP RATE: Select a pump speed close to your desired pump rate otherwise select 50%.

Once these parameters have been entered, press the **EXIT** key and you will return to the screen above. Press "C" to Prime the system, and remove all air from the tubing. Press "A" to Execute, and the following will be displayed:

PR= 50.0%	STOP	
DV=000000	VO=00600ml	
A	B	C

PR = Pump Rate, **DV** = # of Encoder Pulses, and **VO** = Calibration Volume

Whenever possible, use a high resolution balance to measure the amount dispensed during the calibration. Press the **RUN** key, and allow the pump to dispense until the volume gets very close to the calibration volume, and press the **STOP** key. The pump will now display the following:

CAL COMPLETED?		
Yes	No	Exit
A	B	C

If you are satisfied with the amount dispensed, press "A" for Yes. If you need to dispense more, press "B" for No, and you will be returned to the previous display and may press **RUN** and **STOP** again to "top off" the calibration volume. This is much like topping off your car's tank at the gas station, in that you want to get as close as you can without overshooting very far. If you've missed by a long way, and want to try it again, press the **EXIT** button, and you can reenter the calibration menu and run it a second time. Once the calibration is complete, press the **EXIT** key to return to the Mode Select menu.

Program Editing and Execution:

At this point, you need to consider the parameters of the reaction you are feeding and determine if you need to meter at a constant rate, a linear rate, or an exponential rate. Up to three user-definable alarms may be utilized to monitor the pumping rate, the cumulative weight or volume, and when the end of the program has been reached. All the alarms may be set to “Off” (disabled), “Beep Only” (an audible alarm), and “Stop pump” (stops the pump and sounds the audible alarm).

1. Volume Flow: Alarm, ChemTec Manual Section 5.0, Pg B10, 11

Press the “EXIT” button several times to reach the top of the menu. This display is seen:

Mode Selct		MASS FLOW
Up	Down	Select
A	B	C

Press “A” to scroll up until the following appears:

Mode Selct		VOLU FLOW
Up	Down	Select
A	B	C

Press “C” to Select, and this screen now appears:

- VOLU FLOW -		
Exec	Edit	Alarm
A	B	C

Pressing “C” for Alarm gives you access to the following Alarm parameters:

CUMULATIVE VOLUME: Alarm will occur when a user-definable cumulative reagent volume limit has been dispensed. Press “C” to Select, then use “A” and “B” to increase or decrease the amount, up to a total of 99,999 ml. (depending on the calibration units), then press “C” to Select the amount.

VOLUME: Set the appropriate option for the above limit alarm, **OFF**, **Beep Only**, or **Stop Pump**. Use “Stop Pump” if this is a critical alarm. Press “C” to select, “A” and “B” to scroll thru the selections, and “C” again to select.

END OF PROGRAM: Set the appropriate alarm option if you wish to be alerted when your mass flow program has come to an end.

PUMP RATE: This alarm will alert you when your selected pump rate cannot be maintained over any 60-second interval. This will occur if the media reservoir has become empty, the system has sprung a leak, or if the pump rate selected is beyond the capacity of the pump head. The pump will ramp up to 100% of pump speed for 30 sec. before triggering the alarm. If this is a critical parameter, this alarm should be set to “Stop Pump”.

2. Volume Flow: Edit /Execute, ChemTec Manual Section 4.0, Pg B8, 9

The ChemTec will dispense volumetrically over time intervals and at rates that are user specified in a program that is either generated from the front panel, or uploaded from a PC. The ChemTec will only store one Volume Flow program at a time. When generating or editing a Volume Flow program, all program statements that you want to see implemented

during a specific timing block or interval must precede the TIME statement for that timing block. All programs contain a START statement, and an END statement that cannot be deleted. We will look at a simple Volume Flow program, and how the statements are implemented from the Front Panel of the ChemTec.

From the earlier screen, press “B” to select Edit instead of Alarm.

- VOLU FLOW -		
Exec	Edit	Alarm
A	B	C

You will then see the following display. Also shown are all the buttons on the Front Panel.

000 START		000	
Next	Delete	Last	
A	B	C	
RUN	RATE	◀ ▶	EXIT
STOP	TIME	SWITCH	*

In the top window, the first set of **000**'s indicates the statement number, and then is shown the program statement, and the final set of **000**'s will show the number of statements in the existing program. The “A” key will get you to the **Next** statement in the program, the “B” key will **Delete** the displayed statement, and the “C” key will take you to the previous (**Last**) statement in the program. In order to replace a statement with a different one, press “B” to **Delete** the statement that is in error, then press “C” to go to the **Last** statement, and enter the new statement.

The keys allow you to input the following:

RUN: This key inputs a RUN statement, instructs the ChemTec to turn on the pump motor. It is also used to execute a program in response to the message “Press RUN when Ready” at the beginning of a run.

RATE: Press this key, then select the desired volume flow rate. Be sure the rate chosen does not exceed the rated capacity of the installed pump head/motor/tubing combination. Use the “A” and “B” keys to set the rate, and the “C” key to select it.

◀▶ : Press this key to define the rotation of the pump. This acts as a toggle switch, and allows you to select either clock-wise (CW) or counter clock-wise (CCW).

EXIT: This key when pressed exits the mode you are in and brings the ChemTec up one menu level.

STOP: This key will input a STOP statement, and instruct the ChemTec to stop the pump motor. While the program is running, this key acts as an emergency stop button.

TIME: Use this key to input a TIME statement, use “A” and “B” keys to set the time in hours:minutes, and then the “C” key to select it. This is put at the end of a programming block to indicate the length of time to execute the group of statements since the last TIME statement.

SWITCH: This enters an Sw BITS statement that allows programming of TTL switches 1-4 to provide automated control of external devices.

***** : This key provides access to three other programming statements:

Interpolation Rate: Puts in a linearly ramped pump rate over time specified by a TIME statement. This is the final rate, and the initial rate is the previously programmed rate.

Rotary Valve: Allows programming of two 6-position valves, “V” and “W”. The statement V1 would tell valve “V” to be in position #1.

Sample Count: Using this statement allows you to run the program repeatedly, up to 999 times.

For the purposes of this document, we have a bioreactor that needs to be feed a nutrient solution at the rate of 10ml/min for 2 hours, and then have that rate increase in a linear manner over the next 8 hours to 60 ml/min., continue at that rate for 2 more hours, and then stop. Here's the program that we need to input into the ChemTec:

000	START
001	RUN
002	CW
003	RATE 10ml/min
004	TIME 02:00
005	INTRP 60ml/min
006	TIME 08:00
007	RATE 60ml/min
008	TIME 02:00
009	STOP
010	END

When finished entering the program, press **EXIT**, and then **"B"** for Edit again, and you will see the following screen:

000 START	009
Next	Delete
Last	
A	B
C	

Since the START and END statements cannot be entered manually, and can't be deleted either, they are not included in the line count shown here as 009, when you think it should be 010 or 011. This represents the count of the lines that you actually entered.

After setting the above parameters, it's time to prime the ChemTec if not already primed during the calibration process. Press the **EXIT** key on the front panel until you reach the Mode Select screen. From the Mode Select screen, use **"A"** or **"B"** to go up or down to the **"MANUAL"** mode. You will see following display:

Mode Selct	MANUAL
Up	Down
Select	
A	B
C	

Press **"C"** to Select, and the screen will change to the following:

- MANUAL -	100.0%
Sw=0000	CW
A	B
C	

Press the **"RUN"** key and allow the ChemTec to run until all air is removed from the tubing between the Media Reservoir and the BioReactor. Press the **"STOP"** key to stop the pump.

Pressing the **"EXIT"** on the ChemTec will return you to the Mode Select screen. Use the **"A"** and **"B"** buttons to scroll to the **"VOLU FLOW"** mode. Press **"C"** to Select it, and **"A"** to Execute, and the following screens will be displayed:

VOLU FLOW	10.00ml/m
Press RUN when Ready	

When you are ready, Press the RUN key, and the following screen is displayed:

PR= 10.00ml/m		RUN
CV= 00.0ml		T=00.00
A	B	C

PR= Pump Rate (ml/minute), **CW**= Cumulative Volume, **T**=Elapsed Time (hrs:min), **RUN** = Pump Status.

NOTE: The Cumulative Volume and Elapsed Time values will remain if the process is interrupted and restarted, whether it is via an alarm, or the use of the **STOP** or **EXIT** keys. The only way to reset these values is to power down the pump and turn it back on.

This program demonstrates both a constant and linear feed rate. Refer to Section C of the ChemTec manual for additional examples of programs that generate exponential feeds, time delayed feeds, chromatography applications, and the use of the 6 position rotary valves.

Documentation:

The ChemTec will output data to a printer or a PC at periodic user-definable intervals for archival purposes. The following is an example of that data, and an explanation of the abbreviations used.

```
ChemTec VOLU_FLOW= 1.00ml/m; ALARMS: CV=1; PR=3; EP=1; LIMIT:CV= 0.0ml;
T = 00.00; CV = 00.0ml; PR = 10.00ml/m; VP=0; WP=0; ST=START
T = 00.05; CV = 50.0ml; PR = 10.00ml/m; VP=0; WP=0; ST=RUN
T = 00.10; CV = 100.0ml; PR = 10.00ml/m; VP=0; WP=0; ST=RUN
T = 00.15; CV = 150.0ml; PR = 10.00ml/m; VP=0; WP=0; ST=STOP AL = PR
```

T = TIME: Relative time counter, it resets when the ChemTec is turned off.

CV = Cumulative Volume, this resets when ChemTec is turned off.

PR = Pump Rate, displays the pump rate at that moment in time.

VP = V Position, represents the position of Valve "V" (will be 0 if not in use, otherwise 1-6)

WP = W Position, represents the position of Valve "W" (will be 0 if not in use, otherwise 1-6)

ST = STATUS, Pump Status (Start, Run, Pause, Run, Exit)

AL = ALARM, Print out of Alarm condition. AL=PR represents Pump Rate Alarm, AL=CW represents Cumulative Weight Alarm, AL=EP represents End of Program Alarm.

NOTE: Three alarm levels are defined and displayed in the program header of the printout as follows: **1 = Off** (Deactivated); **2 = Alert** (Metering continues, auditory beep/5V output to remote alarm occurs); **3 = Stop pump** (Stops the pump, auditory beep/5V output to remote alarm occurs). Immediate data printout occurs when RUN, STOP or EXIT keys are pressed, and when an alarm occurs. All other printouts occur at a user definable frequency in hours:minutes. (Mode:Setup, Printer, Time)

SciLog recommends a factory cleaning, testing and recalibration be done to your Smart Pump at least once a year, to maintain the accuracy of the unit and reduce your downtime. SciLog also has loaner units available you can rent if you need to keep production running while SciLog is performing maintenance on your pump. Call us at 800-955-1993 for an RGA and arrange for a loaner if needed. If you have a large number of units, call us, and we can design a preventative maintenance program specifically for your company.

The following chart shows tubing dimensions and the available flow rates based on tubing and motor size:

MasterFlex Tubing	13	14	16	25	17	18	15	24	35
Tubing ID*: in	0.030	0.060	0.125	0.190	0.250	0.310	0.190	0.250	0.310
Tubing OD*: in	0.157	0.189	0.251	0.314	0.376	0.439	0.376	0.439	0.500
Tubing Wall*: in	0.063	0.063	0.063	0.063	0.063	0.063	0.093	0.093	0.093
Pump Rate Range*:	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min
CP-8 8RPM	0.03 - 0.45	0.10 - 1.63	0.43-6.38	0.9 - 12.6	1.14 - 18.3	1.7 - 24.3	0.45 - 13	0.65 - 20	0.8 - 32
CP-120 160RPM	0.5 - 10	1.7 - 35.2	6.3 - 129	12.5 - 283	18.5 - 405	24.7 - 554	9 - 260	13 - 435	16 - 650
CP-200 600RPM	2 - 34	8.6- 132	29 - 533	49 - 974	70 - 1048	103 - 1515	59-993	85-1348	111 - 2258
* Nominal Values									
Pump Head Model:	TANDEM 1081						TANDEM 1082		

CAUTION: The following information should be considered and passed along to the operators:

- 1) It should be noted that the ChemTec, once calibrated, will allow you to enter flow rates below those it is actually capable of performing.
- 2) The flow rates on the charts above are nominal values, and it is recommended that you run the ChemTec in Manual Mode at 3% and 100% for a 5-10 min period to determine the min and max flow rates for your specific motor/pump head/tubing combination prior to your calibration and consequent entering of step-by-step instructions.
- 3) SciLog strongly recommends the use of an uninterruptible power supply (UPS) with the ChemTec for long term feed strategies. Its use is also recommended in locations where there are frequent power interruptions and/or fluctuations caused by older building wiring or heating and refrigeration units on the same circuit as the pump.