Calibration Instruction Manual

for the 24 Vdc MagnaValve®

Electronics Inc.
Shot Peening Control

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Table of Contents

Read this manual completely before calibrating a 24 Vdc MagnaValve®.

Introduction

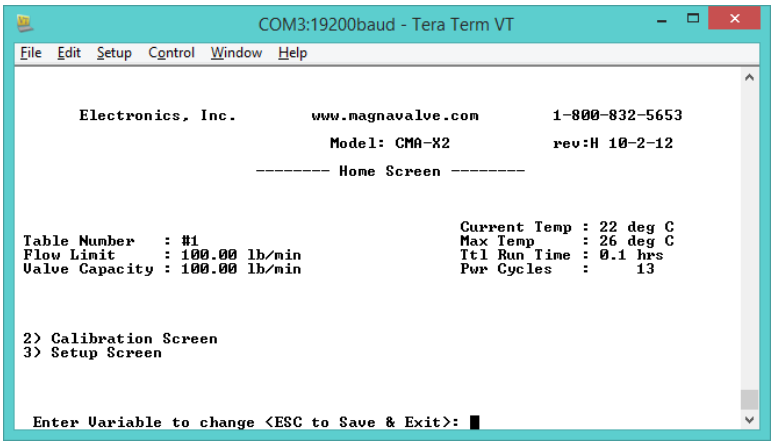
The Calibration Procedures outlined in this instruction manual can be used to calibrate the following 24 Vdc MagnaValves, including those with Remote Table Select (RTS): 500-24, 576-24, 577-24, 578-24, 579-24, 580-24 and 590-24. (For more information on the MagnaValve® with RTS, see the Appendix.) To calibrate the 24 Vdc MagnaValve, the MagnaValve must be connected to a Terminal program via a computer.

Terminal Program Overview

To connect to the Terminal program, see page 16.

Home Screen

The Home Screen provides operational status data plus access to two other screens: 2) Calibration Screen and 3) Setup Screen. The Setup Screen is used for the basic setup. Its parameters are set at the factory and generally do not require changes. The Calibration Screen allows the user to set the maximum (full-scale declaration) flow rates and manipulate the MagnaValve's performance.



Home Screen Functions

Table Number: Displays the Table Number currently in use. The MagnaValve can store data in five different tables, allowing for five different calibrations of media sizes and types.

Flow Limit: Displays the calibration flow rate. In the above example, the output voltage is 10 Vdc when the MagnaValve is flowing 100 lb/min.

Valve Capacity: Displays the maximum flow rate with the selected shot size

Current Temperature: Displays current temperature measured by the MagnaValve

Maximum Temperature: Displays the maximum temperature recorded by the MagnaValve

Total Run Time: Display the total time that the MagnaValve has been powered.

Power Cycles: Number of times the MagnaValve has been powered on and off

Home Screen Functions

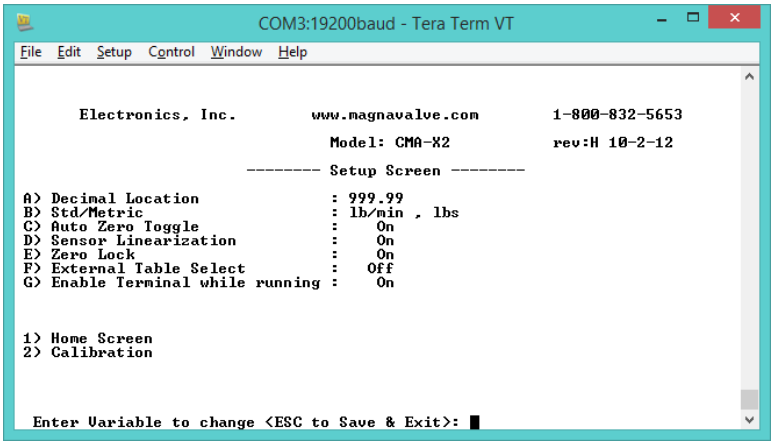
Press 2 on the keyboard to access the Calibration Screen

Press 3 on the keyboard to access the Setup Screen

Press ESC to display a blank screen and terminate the connection between the computer and the MagnaValve. Connection can be re-established by pressing the spacebar on the computer keyboard. At the end of the work session, terminate the connection between the computer and the MagnaValve and unplug the cables.

Setup Screen

Press 3 on the keyboard to access the Setup Screen. The Setup Screen displays MagnaValve settings. The factory settings should be used whenever possible.



Setup Screen Functions

A) Decimal Location: Selects the decimal point in the display of the entered catch weights: 999.99 (recommended for air-blast machines) or 9999.9 (recommended for wheel-blast machines). Pressing A on the keyboard will toggle between the two values.

B) Std/Metric: Selects the display of catch weight either lb/min (default) or kg/min. Pressing B on the keyboard will toggle between lb and kg.

C) Auto-Zero Toggle: Activates or deactivates the auto-zero function. The auto-zero routine will establish zero output voltage automatically thus accommodating minor output signal voltage changes that occur with time or temperature.

Auto-zero On: When the MagnaValve is not enabled, the function will automatically establish a zero output signal unless the MagnaValve's sensor detects signal greater than 10%, thereby detecting an abnormal end-of-cycle condition. This indicates a possible malfunction such as the sensor not being purged at the end of a cycle. When the MagnaValve is enabled, the unit will hold its last established value.

Auto-zero Off: Disables the feature.

Pressing C on the keyboard will toggle between On and Off.

D) Sensor Linearization: Activates or deactivates linearization feature. This feature establishes a linear output transfer function of the sensor signal. A piecewise linearization algorithm is used to translate the as-received sensor signal into accurate (linear) output signal.

Sensor Linearization On: Enables the piecewise linearization algorithm

Sensor Linearization Off: Disables the feature.

Pressing D on the keyboard will toggle between On and Off.

E) **Zero Lock:** Activates or deactivates the zero lock feature. This feature will establish and maintain a zero output voltage even if the sensor detects 0-10% signal level when no Enable signal is applied. The offset will reappear when an Enable signal is applied. An invalid output signal may occur due to metallic dust accumulation within the sensor and this can be suppressed when zero lock is on. Pressing E on the keyboard will toggle between On and Off.

Zero Lock on: When an Enable signal is not present and sensor signal is <10%, the output signal will be 0.0 Vdc. When an Enable signal is present and output signal is normal, there is no influence on output signal.

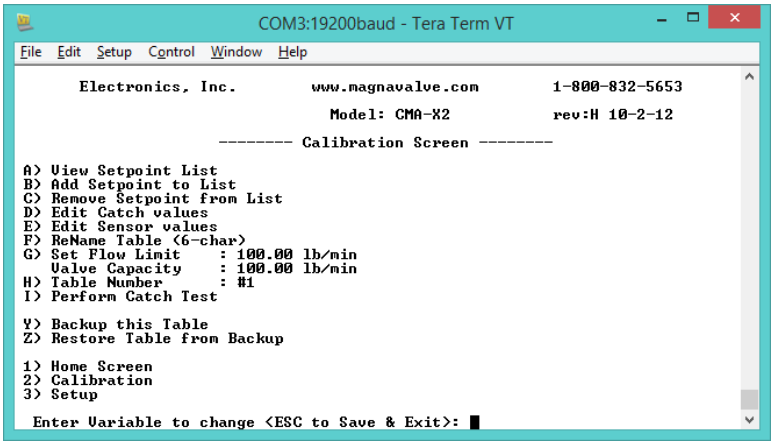
Zero Lock off: There is no effect on the output signal, whether or not there is a PA-24 signal.

F) **External Table Select:** Allows the selection of the desired table remotely through the external Remote Table Select (RTS) connector. Available on 24 Vdc RTS MagnaValves only. See the Appendix for more information.

G) **Enable Terminal while running:** Allows continuous communication with the terminal program. The default value is ON. While "Enable Terminal while running" is turned on, the MagnaValve can be accessed at any time. When this function is OFF, the button on the PA-24 Data Cable must be used to start the terminal program.

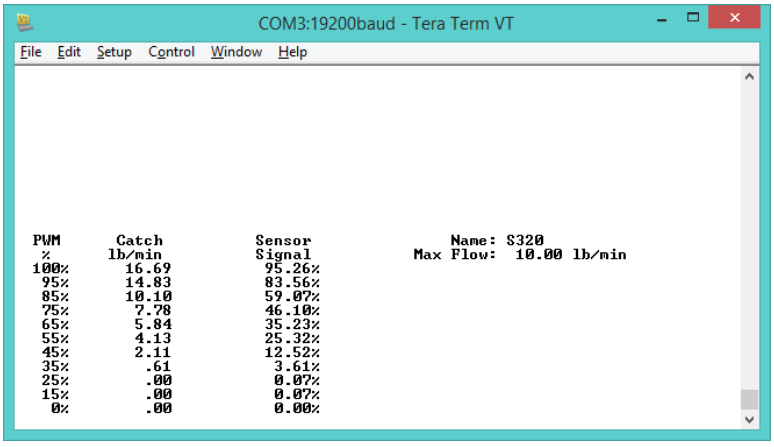
Calibration Screen

Press 2 on the keyboard to access the Calibration Screen. The Calibration Screen allows the user to set the maximum (full-scale declaration) flow rates and manipulate the MagnaValve's performance.



Calibration Screen Functions

A) View Setpoint List: Displays the current calibration table. Pressing A on the keyboard will bring up the following screen.



PWM: Percentage of valve opening

Catch lb/min: Flow rate is lb/min or kg/min for that Setpoint measured during that catch test

Sensor signal: Percentage of signal measured for that Setpoint during that catch test

These values may be copy and pasted into a Microsoft Excel spreadsheet or text file for storage. See "Copying Table to Excel" for more information.

B) **Add Setpoint to List:** Adds up to 10 additional Setpoints for calibration. There are 10 factory Setpoints at 10% increments, starting at 15% ending with 100%. If more accuracy is needed, pressing B on the keyboard will allow additional percentages to be added. When prompted, enter the Setpoint desired. Enter the number only – do not enter a percentage sign.

C) **Remove Setpoint from List:** Press C on the keyboard to remove unwanted Setpoints from the calibration table. For example, if the valve is very linear between multiple Setpoints, the Setpoints in the linear range can be removed to speed up testing.

D) **Edit Catch values:** Press D on the keyboard to change the actual catch weights in the list. May also be used to manually enter data from a spreadsheet or text file.

E) **Edit Sensor values:** Press E on the keyboard to change the actual sensor readings in the list. May also be used to manually enter data from a spreadsheet or text file.

F) **ReName Table (6–char):** Press F on the keyboard to give each of the five tables a unique name. For example: S-70 or S-230. The name has a limit of six characters.

G) **Set Flow Limit:** Press G on the keyboard to change maximum calibration flow rates. This is how much media is flowing when the valve outputs 10 Vdc.

> **Valve Capacity:** This is the maximum flow the valve can do with the selected shot size. This value is automatically filled in when the 100% Setpoint catch test is conducted.

H) **Table Number:** The program provides five separate lookup tables. This allows user to store calibration data for five different shot types or sizes. Press H on the keyboard to toggle among the five tables.

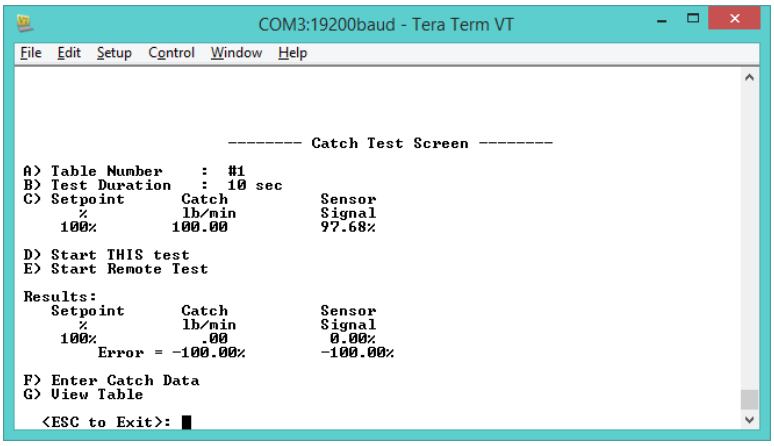
I) **Perform Catch Test:** Press G on the keyboard to access the Catch Test Screen.

Y) **Backup this Table:** Press Y on the keyboard to save the current table's data to a backup location on the MagnaValve.

Z) **Restore Table from Backup:** Press Z on the keyboard to restore the most recently saved calibration data for the current table from the backup location on the MagnaValve.

Catch Test Screen

From the Calibration Screen, Press I on the keyboard to access the Catch Test Screen.



Catch Test Screen Functions

A) Table Number: Press A on the keyboard to toggle among the five tables.

B) Test Duration: Press B to toggle through 10, 20, 30 and 60 second flow tests. Make sure the media catch container will accommodate the amount of media used in the catch test. The test duration is the amount of time the MagnaValve will remain on when "D) start THIS test" is selected. This function is used to conduct a timed catch test when an external timer is not used. (See "Using a Timer.")

C) Setpoint: Press C to toggle through the Setpoint percentages for the catch test, from the highest percentage to the lowest. This function also displays the latest catch weight in the list and the sensor signal measured during the test.

D) Start THIS test: Press D to start a catch test at the requested Setpoint (shown in "C) Setpoint") saved for the requested amount of time chosen in "B) Test Duration."

> **Results:** Displays results from this catch test and the error between the value saved in the table and the test results from this catch test. Press F to save test results.

E) Start Remote Test: Press E to start the selected test remotely through the Enable signal to the MagnaValve. This allows the test to be done under actual flow conditions.

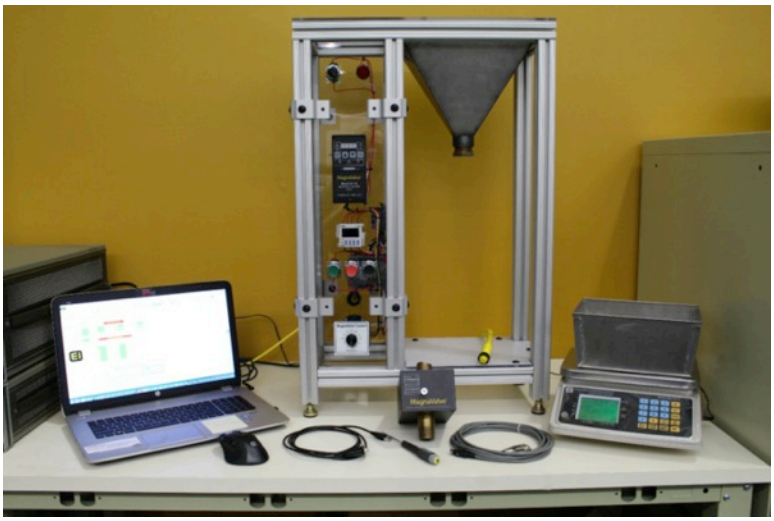
F) Enter Catch Data: Press F to save the test results. **IF TEST RESULTS ARE NOT SAVED, THE RESULTS WILL BE LOST IF A NEW CATCH TEST IS STARTED OR A NEW SCREEN IS OPENED.**

G) View Table: Press G to display the current calibration table.

The Calibration Procedures

A qualified technician should perform a calibration procedure.

Preparing for Calibration



Equipment Needed

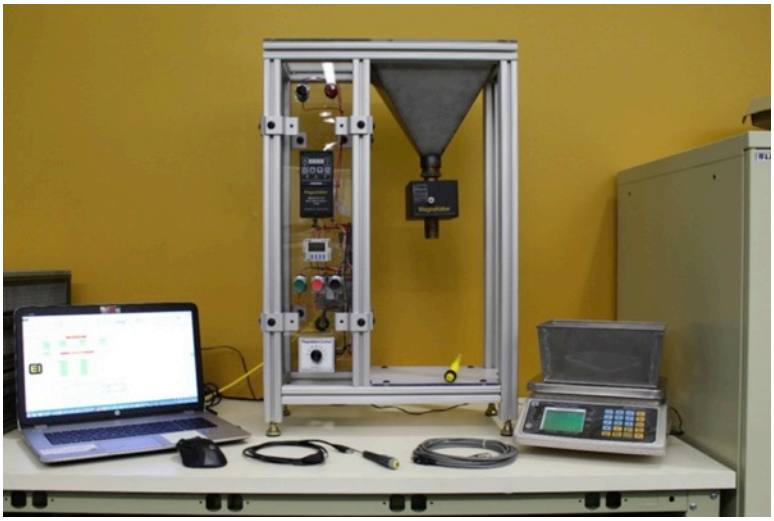
- MagnaValve
- A peening/blasting machine or test stand (shown above)
- Scale capable of weighing total weight caught during a catch test
- Container to catch the media
- Small flat-head screw driver
- Timer with normally open contacts
- Media (not shown)

Additional Equipment for Multi-Point Calibration

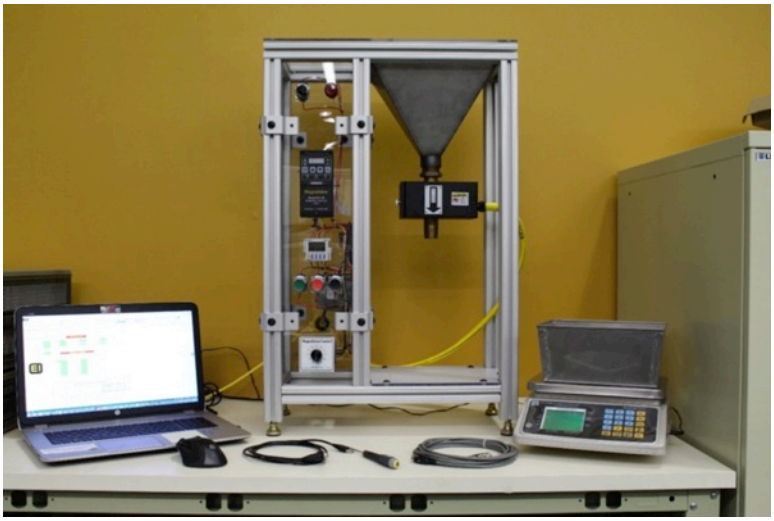
- PA-24 Data Cable
- USB convertor
- Computer with terminal program such as Tera Term or Windows Hyper Terminal

Setting Up the Workstation

Mount the MagnaValve to the test stand or machine.



Connect the power cable to the MagnaValve. Follow the wiring instructions in the MagnaValve's instruction manual.



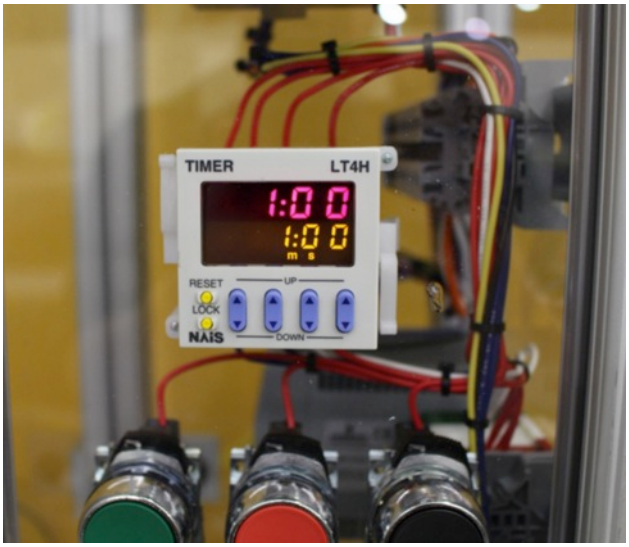
Remove the front cover from the MagnaValve by loosening the captive screw. Apply power to the MagnaValve. The Red Power LED on the front of the MagnaValve will flash for 4 seconds before turning to solid red.

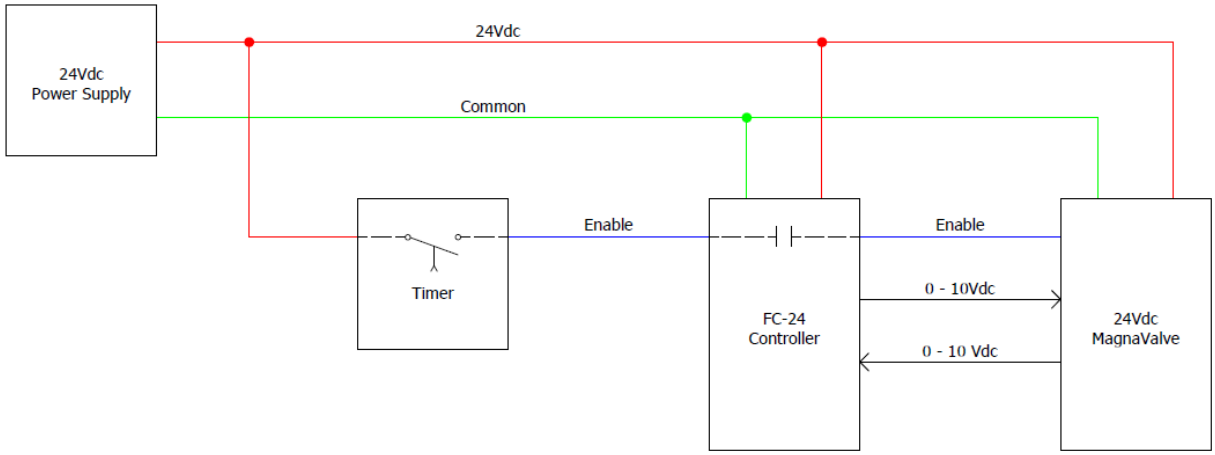
Zeroing the Sensor

Zero the sensor signal on the MagnaValve by using a small flat head screwdriver to adjust the Zero pot until both Green LEDs turn OFF.

Using a Timer

In this workstation, a timer controls the Enable signal to the FC-24 Controller. The FC-24 Controller then feeds the Enable signal to the MagnaValve as shown in the diagram below. The timer provides precise control over the flow duration, therefore increasing the accuracy of the flow rate calculation.





Single-Point Calibration

The purpose of single-point calibration is to fine tune the MagnaValve's performance at a specific operation point or range. The specific operating point can be any point within the operating range of the MagnaValve.

Some common points for a Single-Point Calibration include:

- Full-Scale Value
- Mid-point of the an operating range (for example: 8-12 lb/min, mid-point would be 10 lb/min)
- Operating Setpoint (for example: 8.5 lb/min)

For our example, the MagnaValve will be installed on machine with a flow rate capability of 0–12 lb/min. Due to the machine's flow rate capability, the MagnaValve was initially calibrated for the range of 0-12 lb/min. However, the application requires a flow rate of 10 lb/min. To ensure the best possible performance, a Single-Point Calibration will be conducted at 10 lb/min.

Calculating the Desired Setpoint

To determine the Setpoint value (0-10Vdc input to the Remote Setpoint Pin on the FC-24 Controller) given the desired flow rate, the following equation can be used.

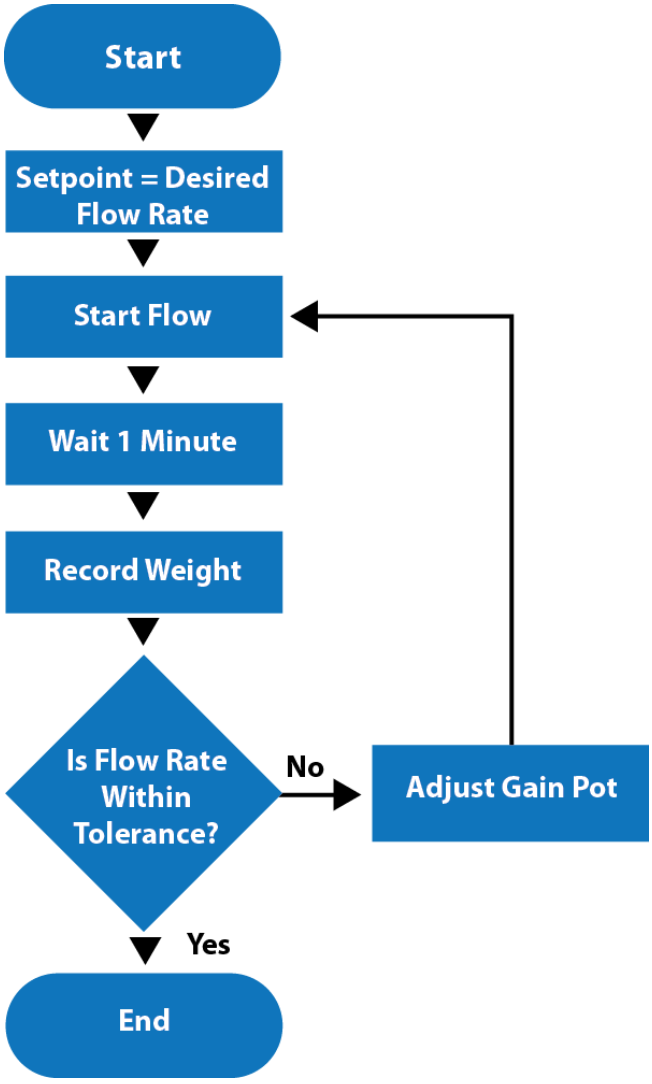
$$Input\ Voltage\ (Vdc) = \frac{10\ Vdc}{Max\ Flow\ Rate} \times Desired\ Flow\ Rate\ (lbs/min)$$

For this example, the Setpoint (input voltage) is:

$$8.33\ Vdc = \frac{10\ Vdc}{12\ lbs/min} \times 10\ lbs/min$$

Single-Point Calibration Procedure

In a Single Point Calibration procedure, a catch test measures the flow rate of the MagnaValve and then the gain is adjusted to increase or decrease the flow rate to meet the tolerance requirement. The Single Point Calibration must always be conducted with the Servo ON (PID-loop enabled). The following flow chart shows the normal steps of a Single Point Calibration.



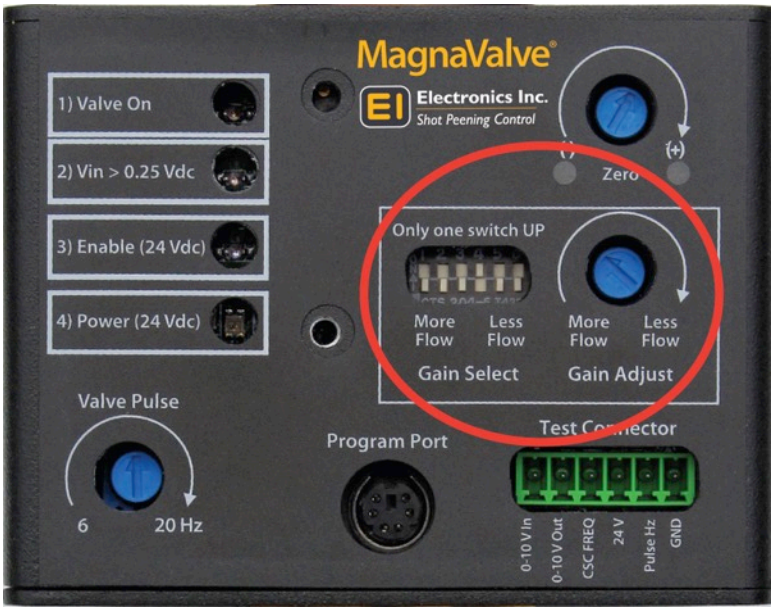
Gain Adjustment

There are two methods of adjusting the gain to increase or decrease the flow rate when the MagnaValve is operating with the Servo ON (PID-loop enabled). The first method is to change the gain on the FC-24 controller. The second method is to adjust the gain on the MagnaValve. This method is used when the MagnaValve is not connected to a FC-24.

To adjust the gain on the FC-24 controller, press and hold the SPAN button and use the up and down arrows to increase or decrease the span. Decreasing the span will cause the flow to increase and increasing the span will cause the flow to decrease.

To adjust the gain on the MagnaValve, adjust the GAIN Pot. To decrease the flow, turn the GAIN Pot knob to the right. To increase flow, turn the GAIN Pot knob to the left. If the GAIN Pot has been turned completely to the right or left and the MagnaValve is still not within the tolerance requirement, the GAIN dip switches can be adjusted.

Warning: Only one dip switch must be in the UP position at a time.



Multi-Point Calibration

Connecting to the Terminal Program

Equipment needed

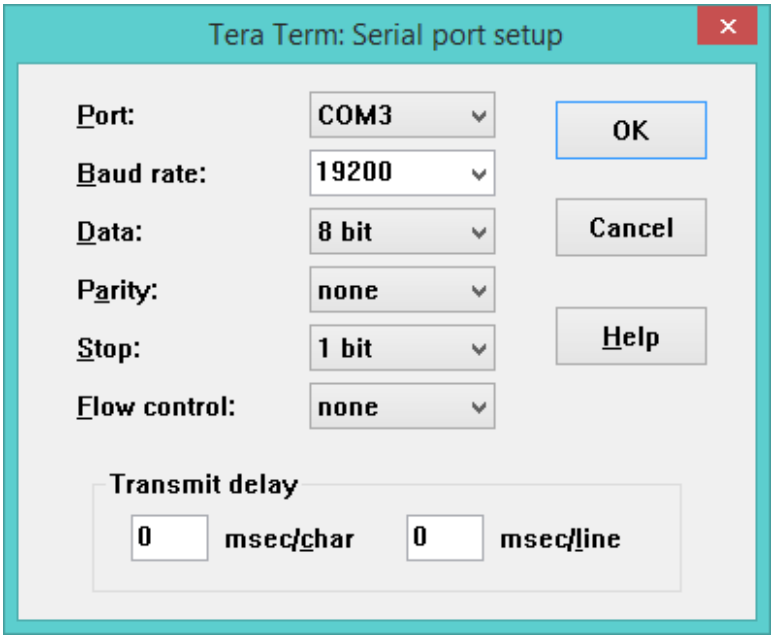
- Windows-based computer with access to a terminal program
- Electronics Inc. PA-24 Data Cable (Part number 980097)
- A USB Adaptor if computer has a USB connector

Remove the front cover from the MagnaValve by loosening the captive screw on the front cover. Attach the MagnaValve Connector (1) of the PA-24 Data Cable to the Program Port of the MagnaValve. Attach the computer connector (2) to the computer's serial port or USB adaptor (attach the USB adaptor to the computer's USB connector).

Note: Depending on the USB convertor, drivers may need to be installed onto the computer.

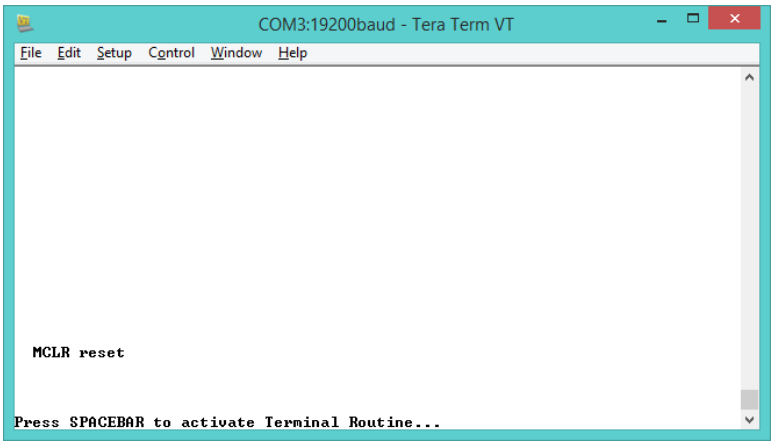
Start the terminal program. In this example, Tera Term is the terminal program but the procedure is the same for any terminal program. Adjust the settings to match those below.

Note: The Port number may not be 3 (COM3) but it must be greater than 1 (COM1).

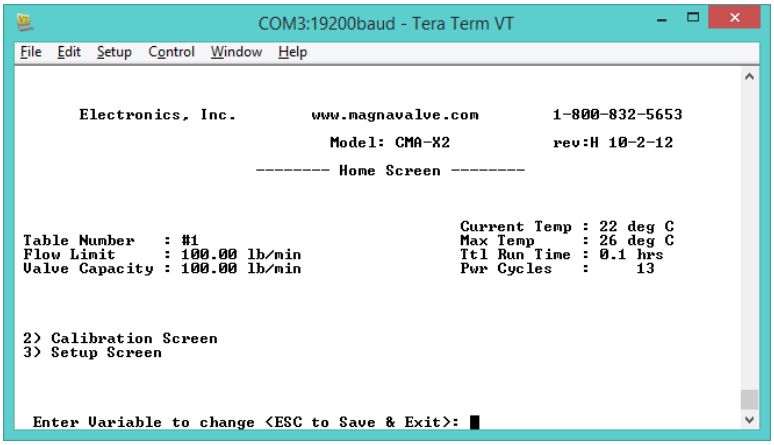


Connect the Terminal program to the MagnaValve by pressing the round button on the PA-24.

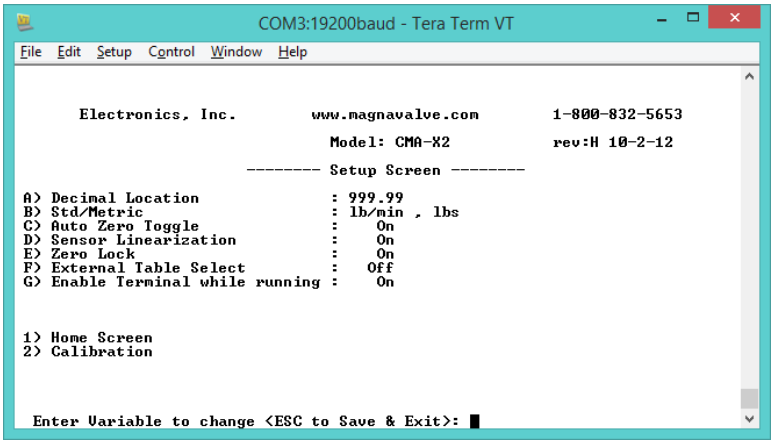
After pressing the button on the PA-24, the following text will appear on your computer screen: **Press SPACEBAR to activate Terminal Routine…**



After pressing the Spacebar, the Home Screen is displayed.

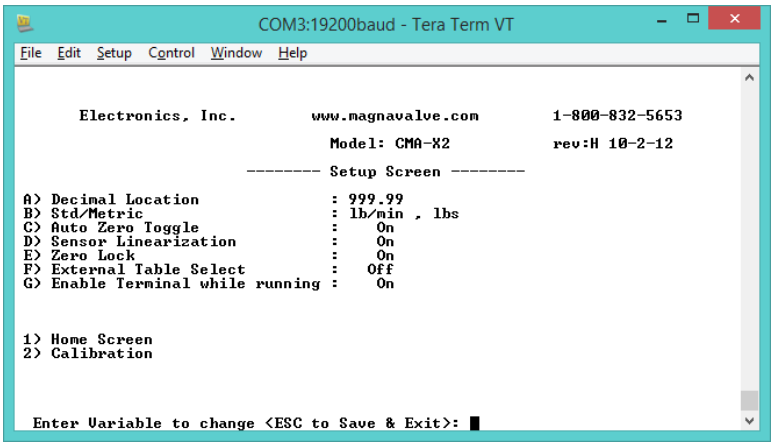


Press 3 to display the Setup Screen.



Setting the Units of Measure

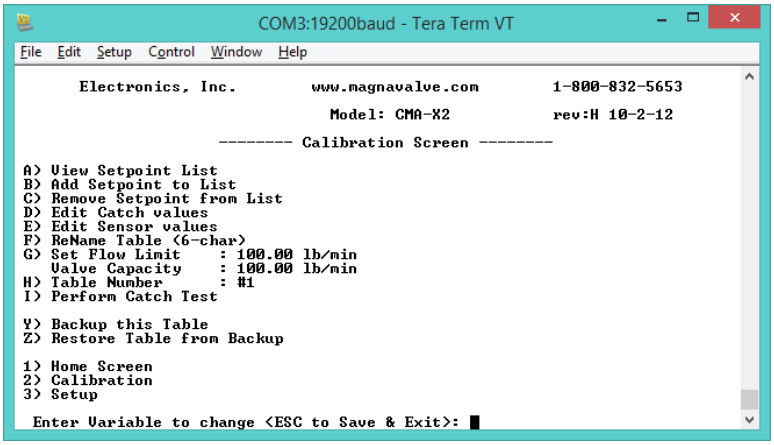
While on the Setup Screen, ensure that the MagnaValve is set to the correct unit of measure for the flow rate. For this example lb/min is used. If the correct unit of measure is not shown, press B to toggle between lb/min and kg/min.



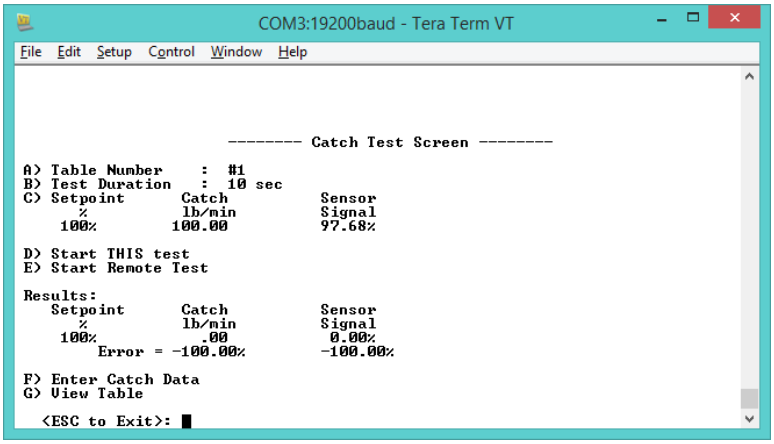
Press 2 on the keyboard to display the Calibration Screen.

Setting the Sensor Gain

You are now at the Calibration Screen.



Press I to display the Catch Test Screen.



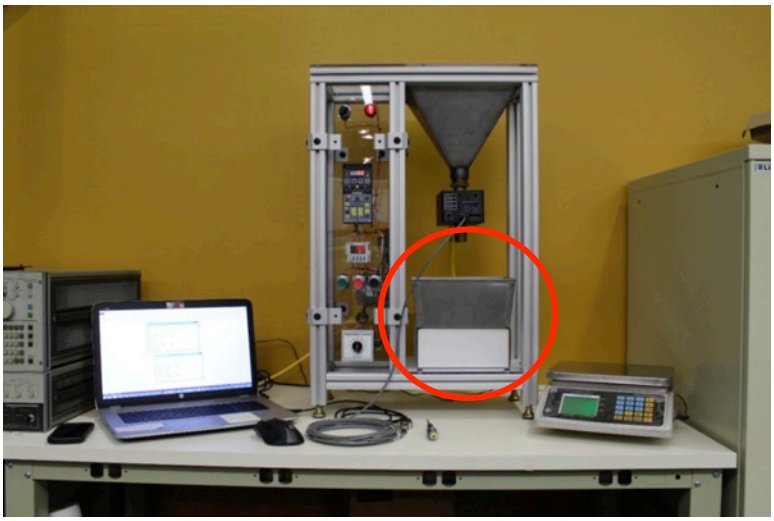
Check to ensure that the correct table number is shown. In the example below, Table #1 will be calibrated. If a different table is to be calibrated, press A on the keyboard to toggle to the correct table number.

Note: When calibrating multiple tables in a MagnaValve, the order in which the shot type and size is calibrated is important. For example, if the MagnaValve is being calibrated for cast steel shot and cut wire shot, the smallest cast steel shot must be calibrated first and the gain adjusted to 95% for that shot. The gain **MUST NOT** be adjusted for any other table calibration, including table calibrations for cut wire shot. If only cut wire shot will be used in the MagnaValve, the smallest cut wire shot must be calibrated first and the gain adjusted to 95% for that shot.

Ensure that the Setpoint shown is 100%. The Catch weight and Sensor Signal value is not important at this time. If the Setpoint is not 100%, press C on the keyboard to toggle through the different Setpoints until 100% is displayed.

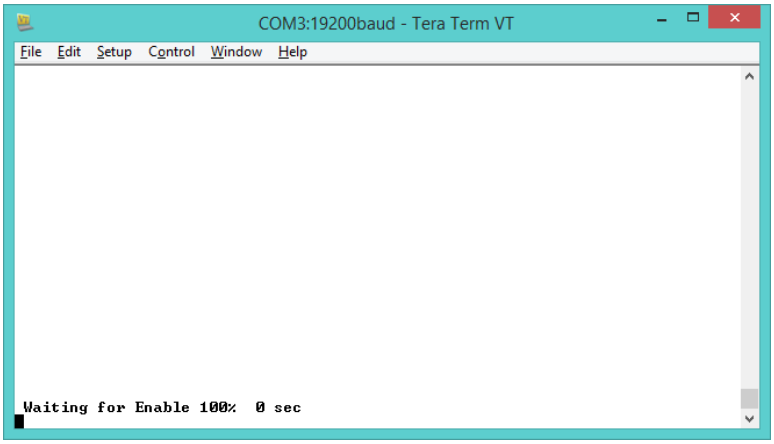
Note: For this example, an external timer and Enable signal will be used to start and stop the test, therefore, “B) Test Duration” is not important. When Remote Test is used, the system will wait until an Enable signal is applied before starting media flow and sampling the sensor. The MagnaValve will continue to flow media and sample the sensor until the Enable signal disappears. (For more information, see “Using a Timer.”)

If “THIS Test” is used, the system will start to flow media and sample the sensor signal immediately after pressing D. The media will flow for a duration equal to the “B) Test Duration.” To change the “B) Test Duration”, press B to toggle through the different Test Duration options.

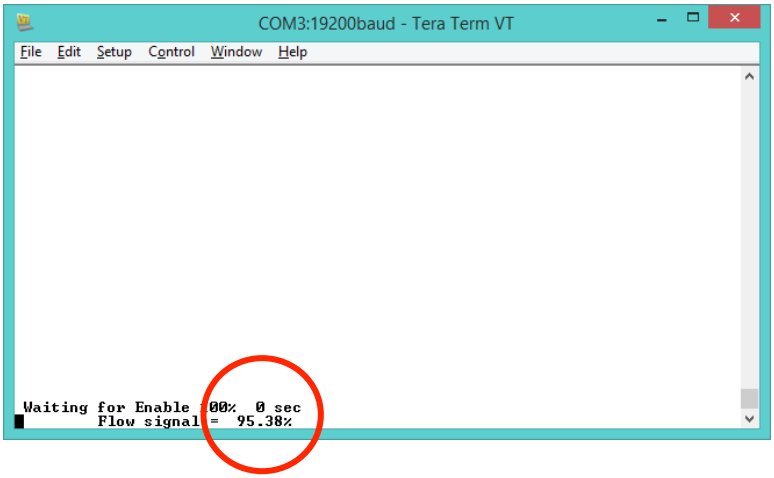


Warning: Don't forget to place a media catch container below the valve if using a test stand.

Press E on the keyboard. The terminal program will indicate that it is waiting for an Enable signal. Press the start button on the timer.

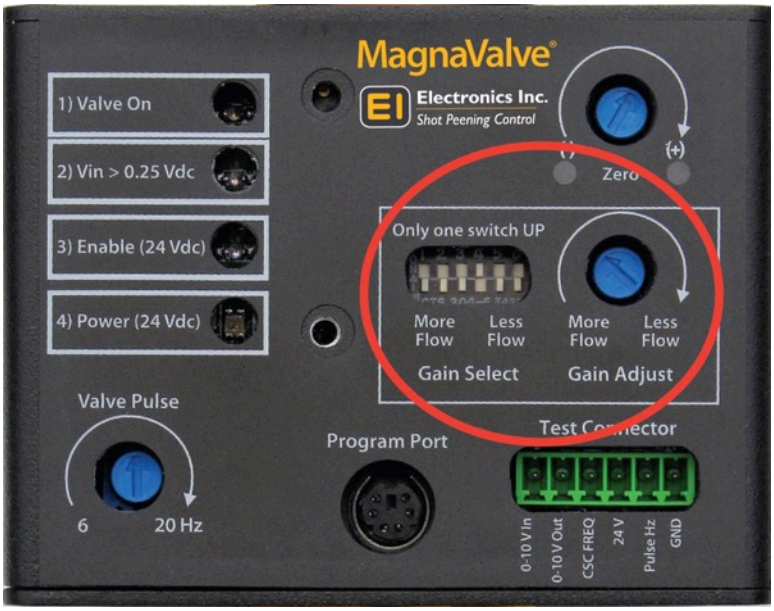


The terminal program will pause for about 5 sec. before starting to sample the sensor signal. Once the sampling starts the terminal program will display the measured signal percentage.



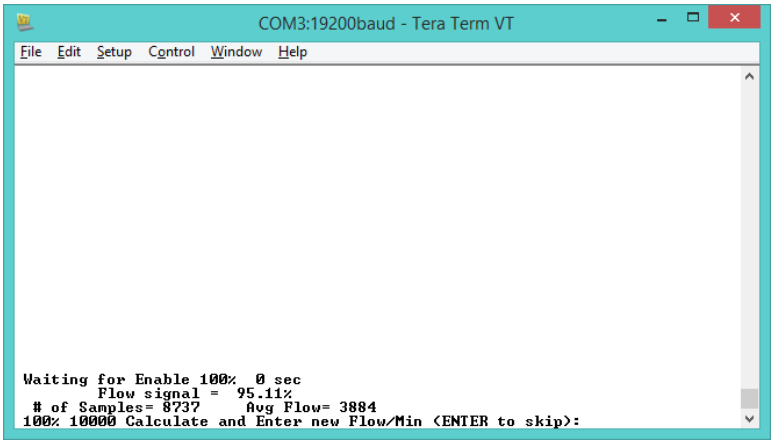
While media is flowing, the Gain dip switch and Gain pot on the MagnaValve must be adjusted to achieve approximately 95% Flow signal.

Warning: Only one dip switch must be in the UP position at a time.

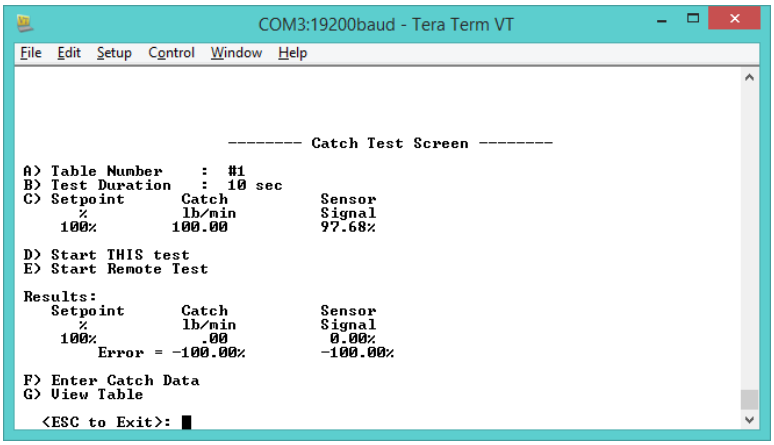


Warning: After the timer stops the flow, the terminal program will request the flow rate for that test. Press ENTER on the keyboard to skip this. Since the sensor gain was being adjusted during the test, the recorded sensor signal is not accurate.

Note: If the timer stopped the flow before the gain is properly set, the test can be run as many times at it takes to properly adjust the gain. It is also good practice to run a test one last time after the gain is adjusted.



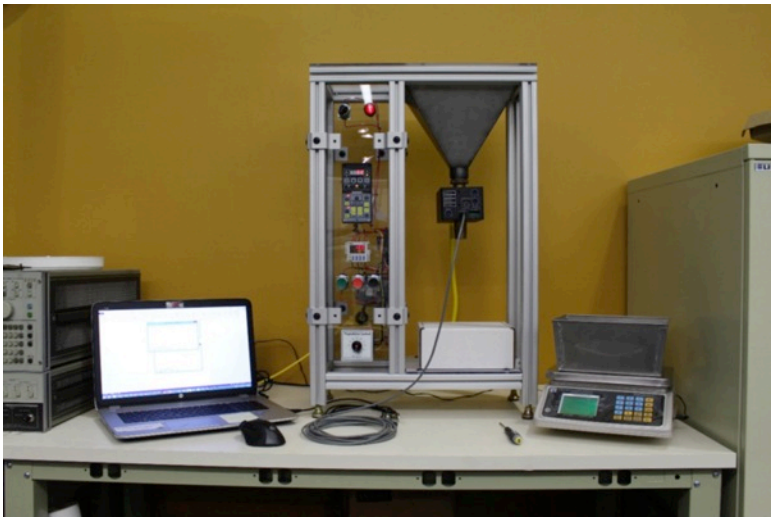
Starting the Calibration



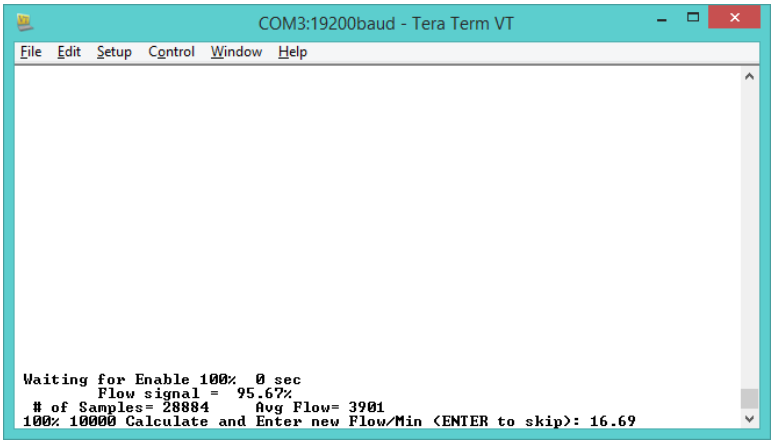
After the sensor gain is properly adjusted, reclaim the media and press E on the keyboard to start the test for the actual calibration.

Warning: For the actual catch test, ensure that the media does not run out during the test. Media must be flowing through the MagnaValve throughout the entire test.

After the timer stops the flow, place the media catch container onto the scale and measure the media caught during the flow duration.



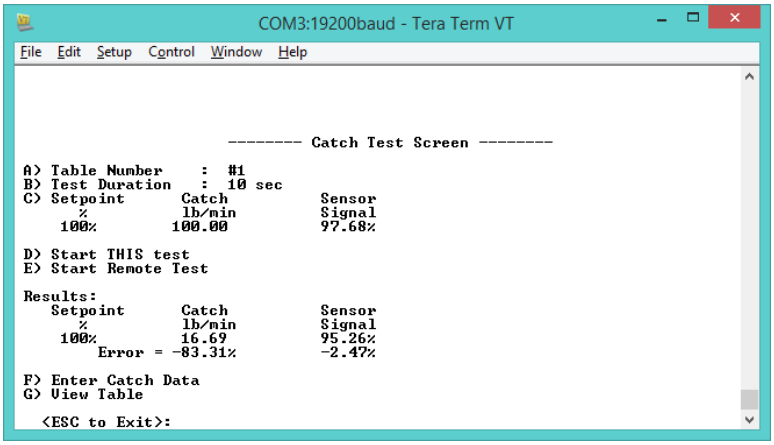
Calculate the flow rate in either lb/min or kg/min depending on the units of measure. Enter the flow rate into the terminal and press ENTER.



Warning: The number entered must be the flow rate, not the weight caught. If test duration was one (1) minute, then the weight caught would be weight per minute. If the test duration was something different than one minute, then the following equation can be used to calculate the flow rate.

$$Flow\ Rate = \frac{Weight\ Caught}{Test\ Time\ (\text{sec.})} \times \frac{60\ sec.}{1\ min.}$$

Warning: The number entered must start with a number. For example: 16.69, 1.25, or 0.97 is acceptable. .87 is not acceptable.



After completing a test, the Catch Test screen will show percent error between what was recorded and what is currently in memory. This error is calculated with this formula:

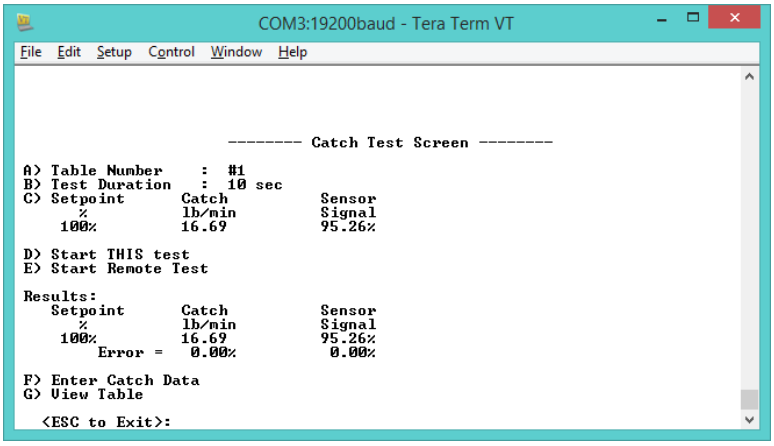
$$Error\ \% = \frac{New\ Value - Current\ Value}{Current\ Value} \times 100\%$$

In this example, the catch weight error is:

$$-83.31\% = \frac{16.69\ lbs/\min - 100\ lbs/min}{100\ lbs/min} \times 100\%$$

The sensor signal error is:

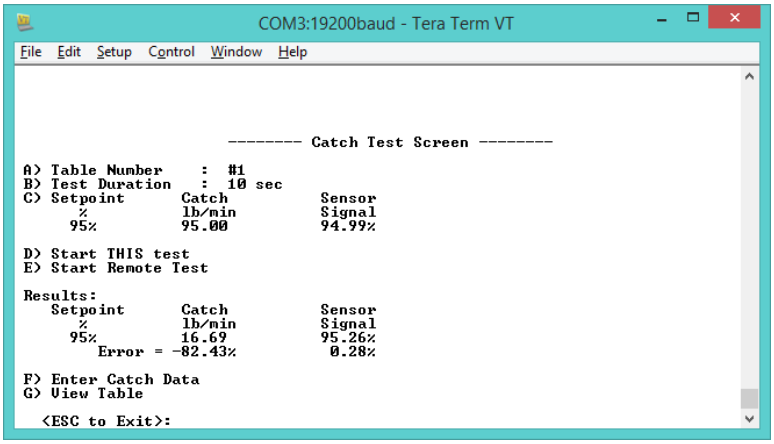
$$-2.47\% = \frac{95.26\% - 97.68\%}{97.68\%} \times 100\%$$



Press F on the keyboard to save the new catch weight and the new sensor signal. Notice that after pressing F, the Error went to 0.00%.

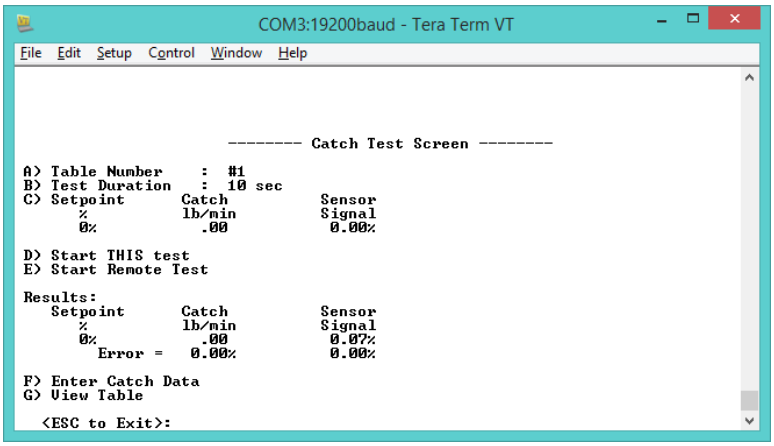
Warning: If F is not pressed, changing the Setpoint or leaving this screen will cause the data to be lost.

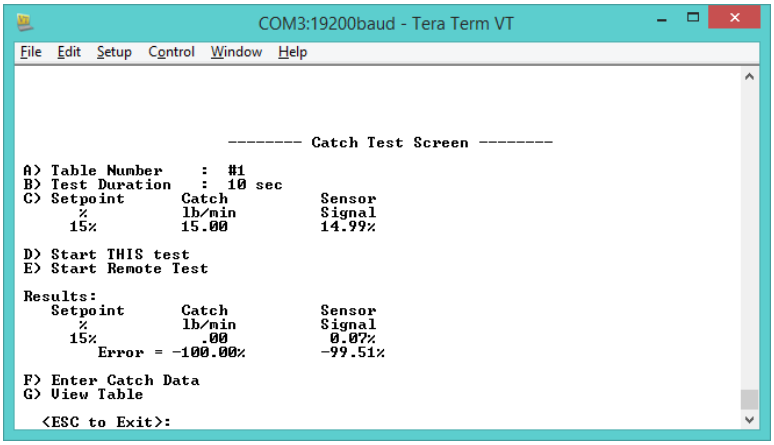
Press C on the keyboard to move to the next Setpoint in the table. Repeat the last five (5) steps until all Setpoints are completed. Remember to press F after each Setpoint catch test.



Note: After changing the Setpoint, the Results section will still display the previous information and the error is recalculated based on the data stored in memory for the new Setpoint. This is not an issue. After running the new Setpoint test, the Results data will be overwritten with the new catch weight and sensor signal.

Warning: DO NOT run Setpoint 0%. By default, the Setpoint 0% is set to 0.00 lb/min and 0.00% sensor signal. It is very important to not overwrite these values. DO NOT run this Setpoint.





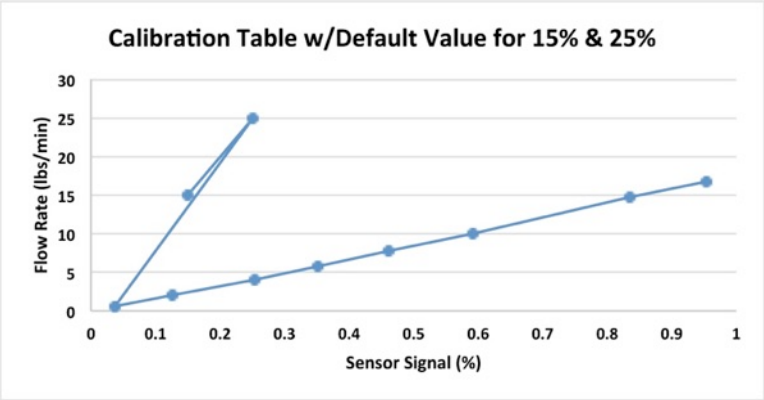
Note: In this example, Setpoints 25% and 15% did not flow media. This is not unusual. In the case where the MagnaValve will not flow media for a Setpoint, run the test and enter 0.00 for the flow rate. By default every table has values written into the table and these default values will cause issues during run time.

The screen shot above, for a 15% Setpoint, shows a default value of 15.00 lb/min for the catch and 14.99% for the sensor signal. In reality, a Setpoint of 15% did not flow any media and it had a ±0.00% sensor signal. This results in a -100% error.

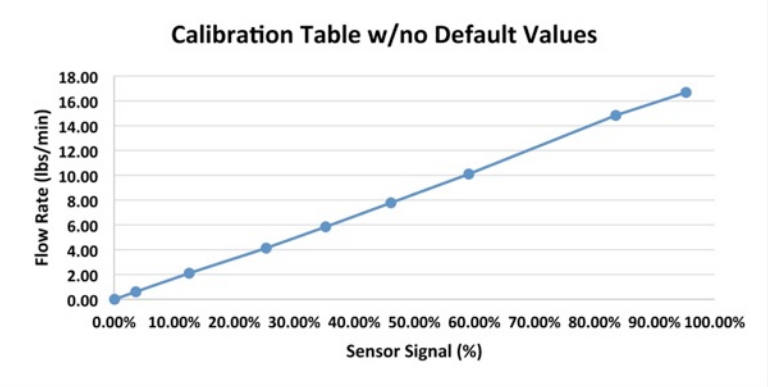
$$-100\% = \frac{0.00\ lbs/\min - 15.00\ lbs/min}{15.00\ lbs/min} \times 100\%$$

For example, if this test was not conducted and 0.00 lb/min was not entered for the 25% and 15% Setpoints, the data table would look like the graph on the next page. Default values in the 25% and 15% causes a range of sensor signals with more than one possible flow rate. This causes confusion in the program and undetermined values will be placed on the Analog Output to the controller.

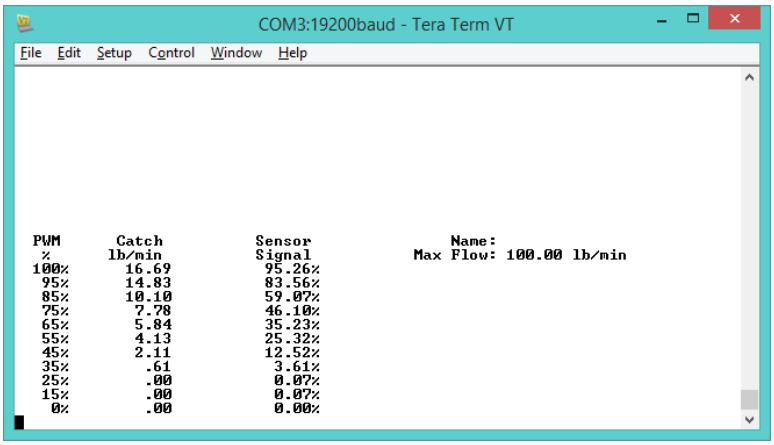
Graph showing default value in 25% and 15% Setpoints



Graph showing a value with 0.00 lb/min entered for the 25% and 15% Setpoints when no media would flow for those Setpoints.



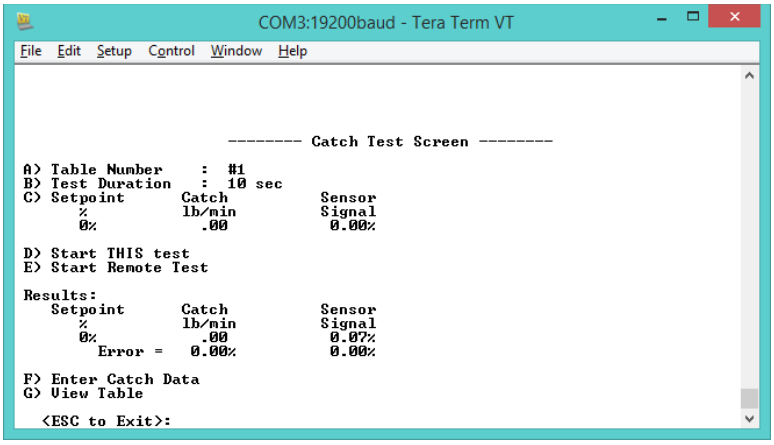
Changing the Flow Limit



After all the Setpoints have been calibrated, press G on the keyboard to view the table. This table has been saved in memory. The table above shows the weight caught and the sensor signal measured for each Setpoint during the calibration. The table name and max flow are also shown. The flow limit is the scaling of the analog output voltage. (How to name the table will be covered in the next section.)

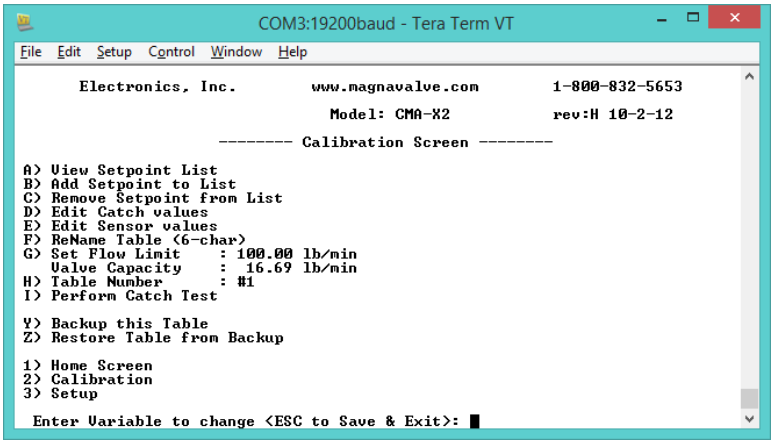
Note: The current table shows the Max Flow equal to 100.00 lb/min, however, the 100% Setpoint had a flow rate of 16.69 lb/min. Not only is it impossible to flow 100.00 lb/min of media through this MagnaValve, but the current application may require only a maximum of 10 lb/min. This can easily be changed by following these steps.

Press ENTER to return to the Catch Test Screen.



Press ESC to return to the Calibration Screen.

On the Calibration Screen, the Valve Capacity is shown as 16.69 lb/min. This is the maximum possible flow for this MagnaValve. The flow limit shown is 100.00 lb/min.



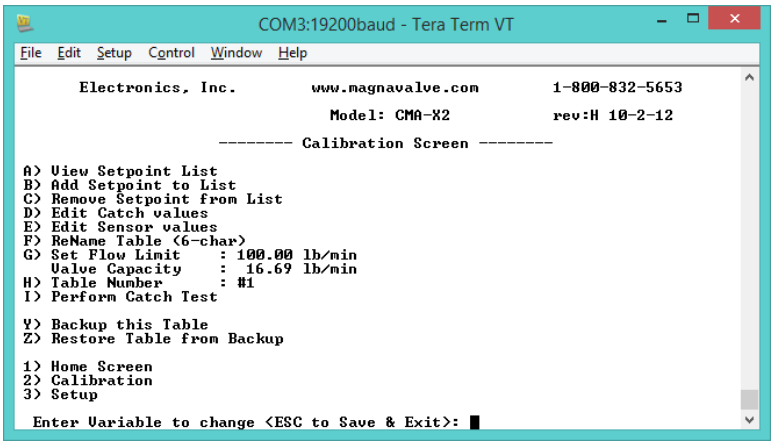
To change the flow limit, press G on the keyboard and enter the new value. For this example, the Flow Limit will be set to 10.00 lb/min.

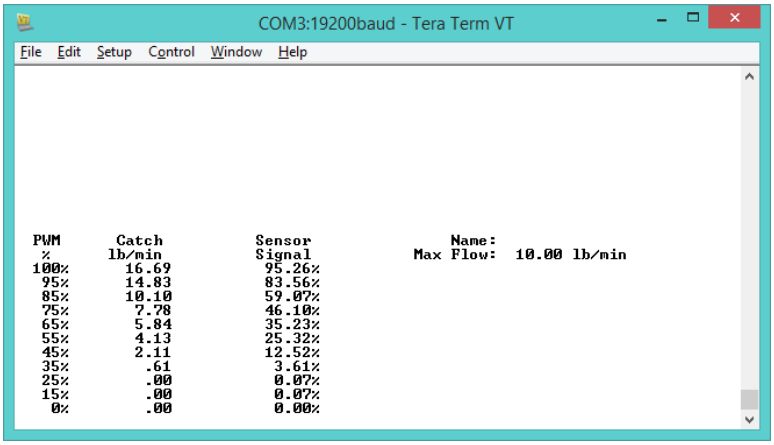
The Flow Limit changes the scale of the 0-10V Analog Output such that 0-10Vout represents 0-Flow Limit. In this case 0-10 Vout will represent 0-10 lb/min of flow rate.

Intermediate values of the Analog Output can be calculated by using the flowing equation:

$$Vout = \frac{10V}{Flow\ Limit} \times Instantaneous\ Flow\ Rate$$

Press I on the keyboard to return to the Catch Test Screen and then press G to view the table.

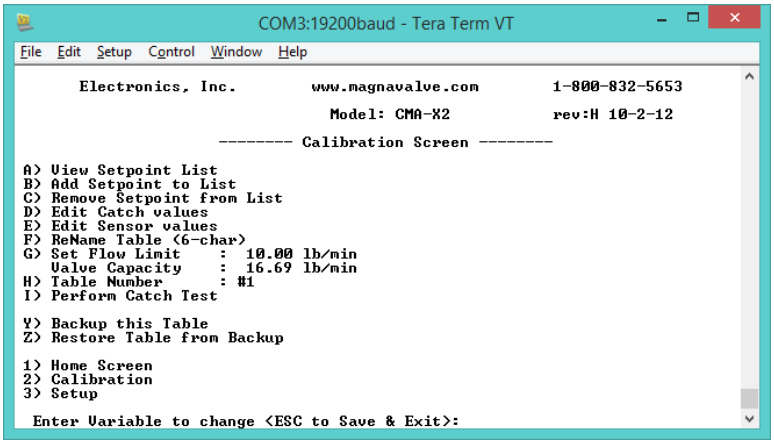




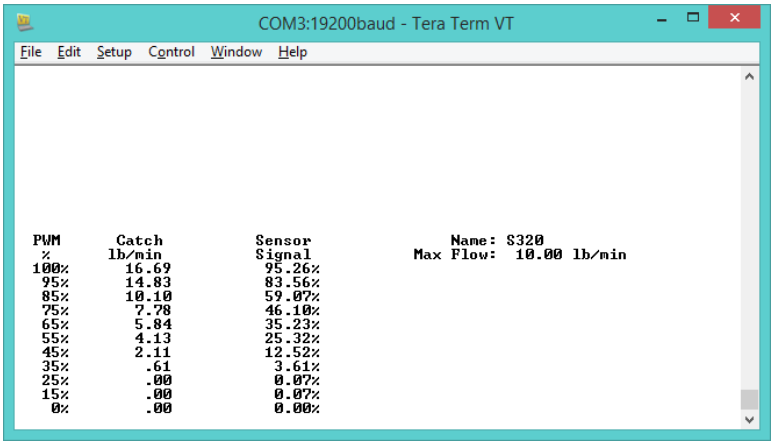
Notice the Max Flow had changed to 10.00 lb/min, however, the name of the table is a blank space. To name the table, press ENTER to return to the Catch Test Screen and press ESC to return to the Calibration Screen.

Naming the Table

On the Calibration Screen, press F on the keyboard to enter a name for the current table. Enter the desired table name and press Enter.



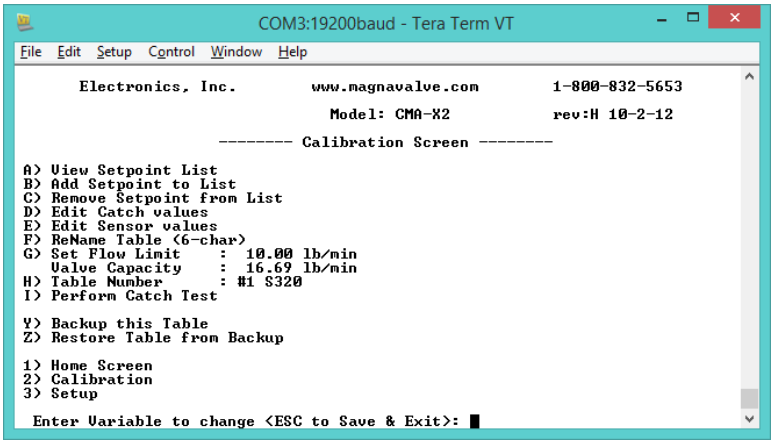
In this example, S-230 will be entered because S-230 was used during the calibration of the MagnaValve. Press I on the keyboard to return to the Catch Test Screen and press G to view the table.



The table is now named S230. Press ENTER to return to the Catch Test Screen and press ESC to return to the Calibration Screen.

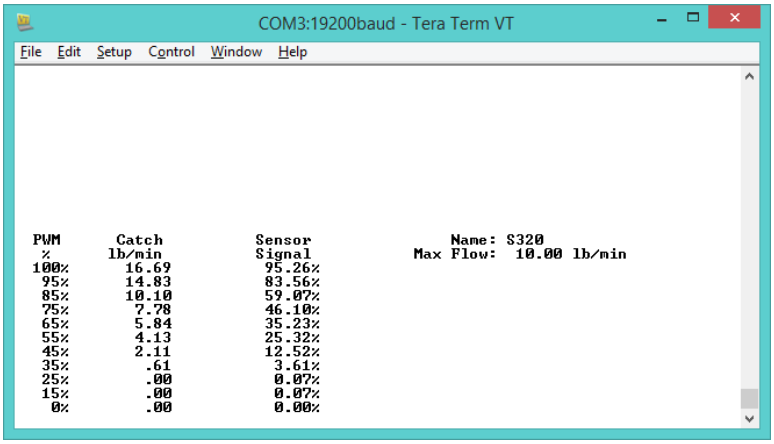
Backing Up the Table

While on the Calibration Screen, the current table can be backed up by pressing Y on the keyboard. This will save a copy of the active table to memory for recovery.

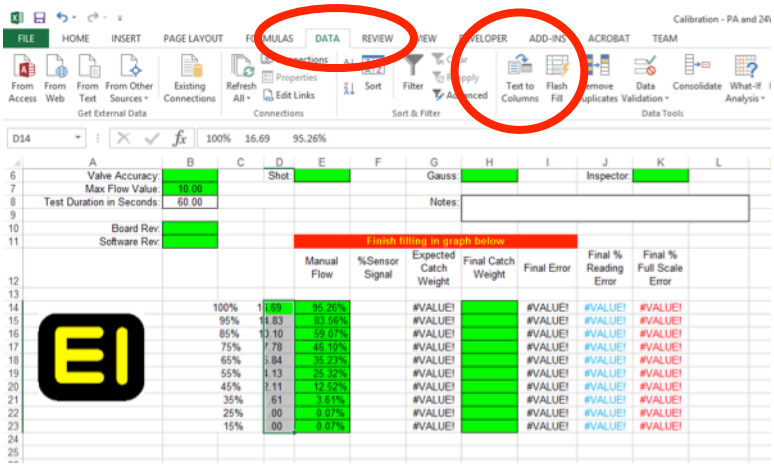


Copying Table Data to Excel

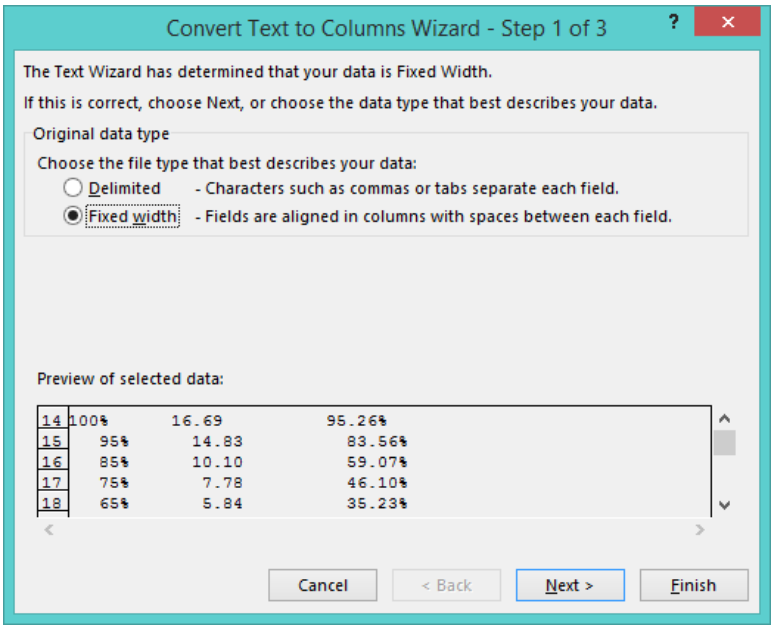
To copy the data from the terminal program, left click before the 1 in 100%, hold down the left mouse button, and drag the mouse to just after the % in 0.00%. Then press CTRL+C. This will select and copy the whole table.



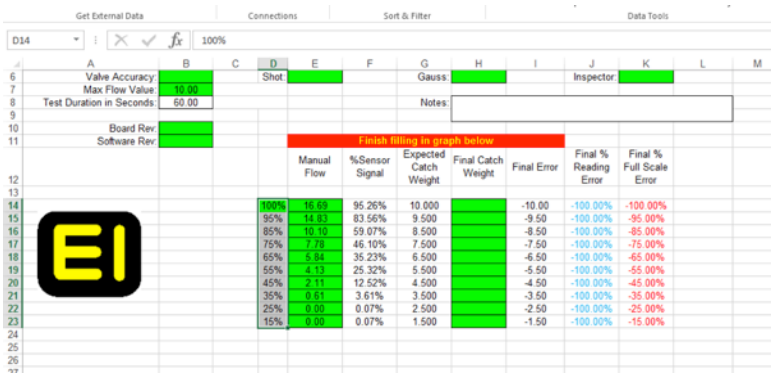
To paste the data into Excel, click on the cell in Excel where the data is to start. In this example, the data is to start at D14. Use a normal paste command (click on the cell and press CTRL+V). All the data is copied to that one column and 10 rows. To move the data across the three columns, click on the Data tab and then click on Text to Columns.



This window will pop up, click Finish.



The data is now pasted into its own cells.

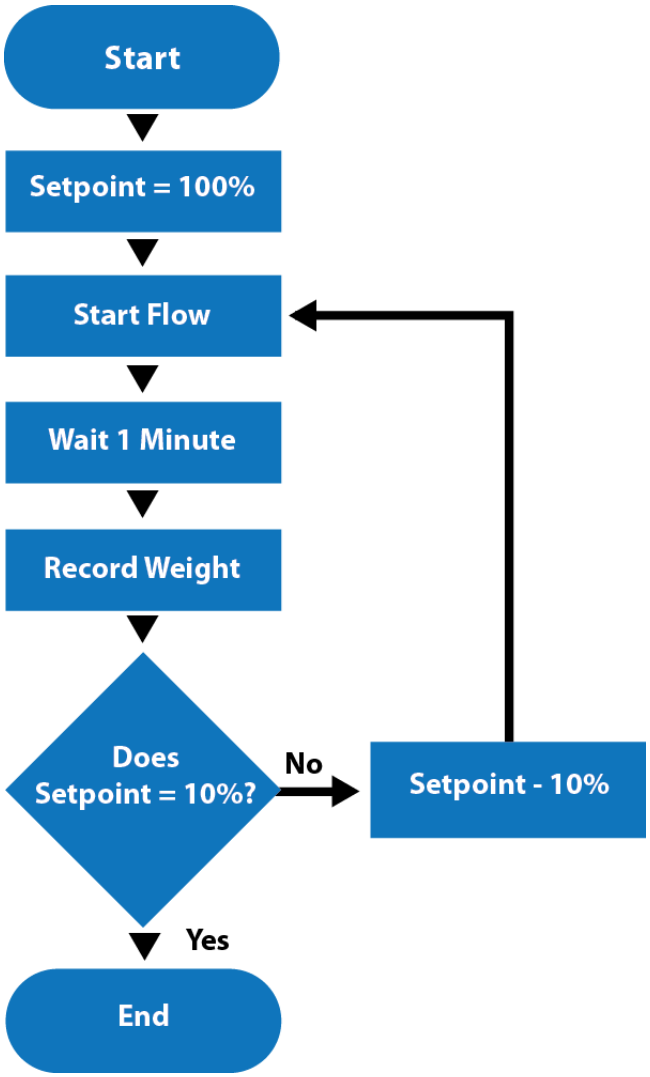


Closed-Loop Catch Test

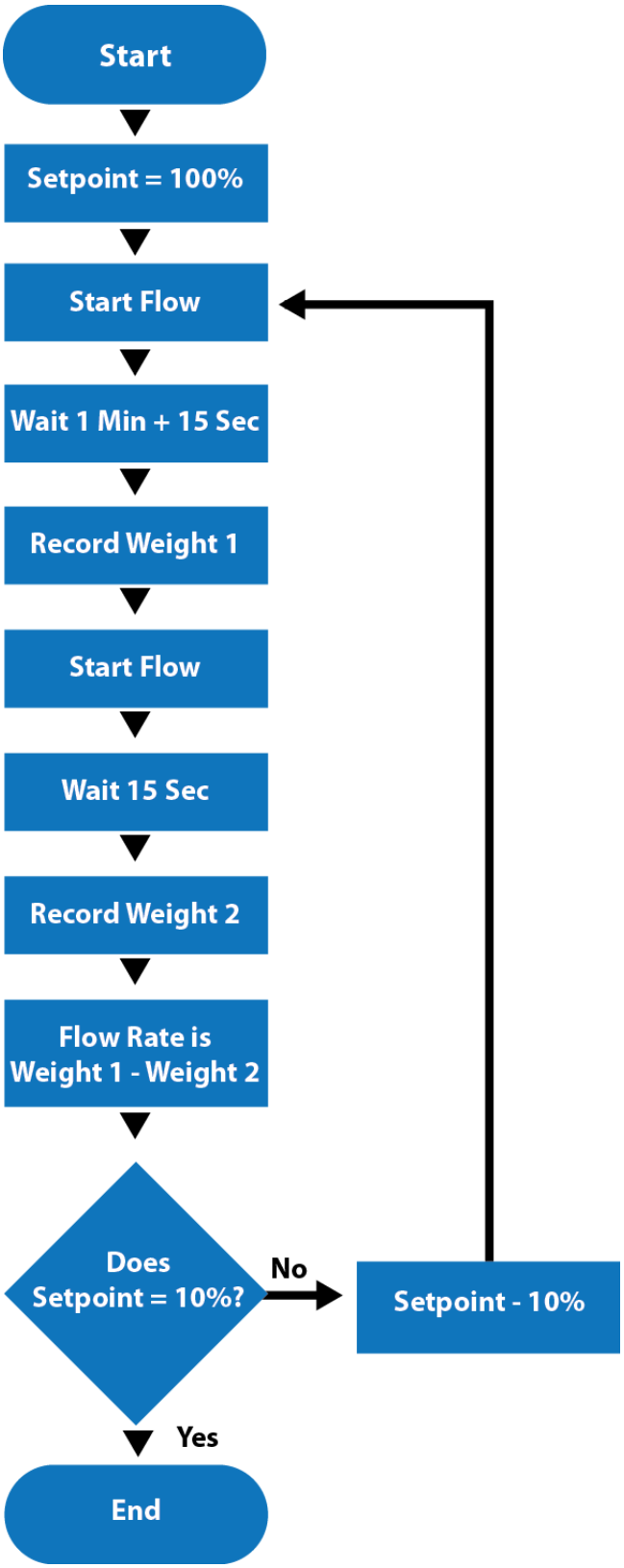
A closed-loop catch test is recommended after calibrating the MagnaValve. A closed-loop catch test is a catch test at several different Setpoints across the operating range where the MagnaValve is controlled by a PID loop (servo ON). This group of catch tests are then compared to an ideal response of the MagnaValve to ensure that the calibration is accurate within an expected tolerance. For this example, a FC-24 Controller will be used to control the MagnaValve. The FC-24 Controller was designed to work with the MagnaValve and it has a built-in PID loop. The PID loop, however, will slowly increase the flow through the MagnaValve until the desired flow rate is achieved. This slow ramp-up to the desired flow rate adds error to the catch test.

The added error can be compensated for by doing one catch test for 1 minute plus 15 seconds (75 seconds) and another catch test for 15 seconds. The results from the catch test run at 15 seconds can then be subtracted from the results from the catch test run at 75 seconds.

The following flow chart shows the normal steps when doing a closed-loop catch test without compensating for the ramp-up of the PID loop.



The following chart shows the steps required to conduct a compensated closed-loop catch test.

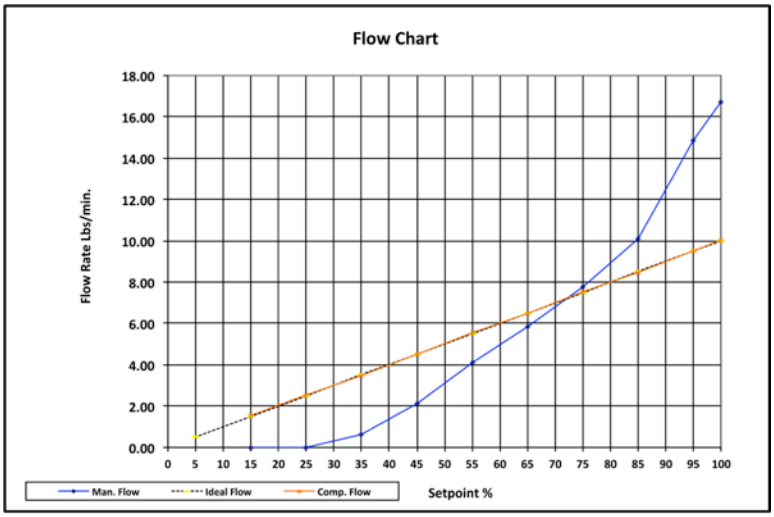


The Excel spreadsheet below shows the compensated flow rates (column H, rows 14-23) measured using the compensated closed-loop catch test technique described earlier. Notice the ideal (expected) catch weight in column G, rows 14-23. The percentage error is then calculated using the ideal (expected) catch weight and the final catch weight. The percentage error of full scale is shown in column K, rows 14-23 and percentage error of point is shown in column J, rows 14-23. For more information on percentage error, see the next section, "Calculating Percentage Error."

	B	C	D	E	F	G	H	I	J	K	L
4	577-24		Scale#:			Amps:			F(FS)Hz:		
5			Test Procedure:			Pulse Rate:	8		Delta:	0	
6			Shot:			Gauss:			Inspector:		
7	10.00										
8	60.00					Notes:					
9											
10											
11				Finish filling in graph below							
12				Manual Flow	%Sensor Signal	Expected Catch Weight	Final Catch Weight	Final Error	Final % Reading Error	Final % Full Scale Error	
13											
14			100%	16.69	95.26%	10.000	10.006	0.01	0.06%	0.06%	
15			95%	14.83	83.56%	9.500	9.502	0.00	0.02%	0.02%	
16			85%	10.10	59.07%	8.500	8.476	-0.02	-0.28%	-0.24%	
17			75%	7.78	46.10%	7.500	7.536	0.04	0.48%	0.36%	
18			65%	5.84	35.23%	6.500	6.513	0.01	0.20%	0.13%	
19			55%	4.13	25.32%	5.500	5.574	0.07	1.35%	0.74%	
20			45%	2.11	12.52%	4.500	4.533	0.03	0.73%	0.33%	
21			35%	0.61	3.61%	3.500	3.495	0.00	-0.14%	-0.05%	
22			25%	0.00	0.07%	2.500	2.523	0.02	0.92%	0.23%	
23			15%	0.00	0.07%	1.500	1.545	0.04	3.00%	0.45%	
24											
25											
26											
27											

The results for the MagnaValve calibration and the closed-loop catch test can be graphed as shown below. The blue line is the data saved in the MagnaValve's memory. The orange line is the closed- loop test results.

Notice the maximum flow rate is 16.69 lb/min and the calibrated maximum flow rate is 10.00 lb/min.



Calculating Percentage Error

The percentage error is the total percentage of all errors in taking a measurement. This error contains the uncertainties in the MagnaValve, the uncertainties in the scale used to measure the flow rate, and the uncertainties in the timer used to control the flow while measuring the flow rate.

The % error can be calculated two main ways, percentage error of full scale and percentage error of point. This percentage error can then be used to validate the peening process.

Percentage Error of Full Scale

Percentage Error of full scale can be described as the possible constant error band across the complete operating range. The tolerance band is calculated at the full-scale value (100% Setpoint) and that percentage is used at all points along the operating range. In this example, the MagnaValve was calibrated for 10 lb/min. If the tolerance for this valve were +/-5% of full scale, the tolerance band would be:

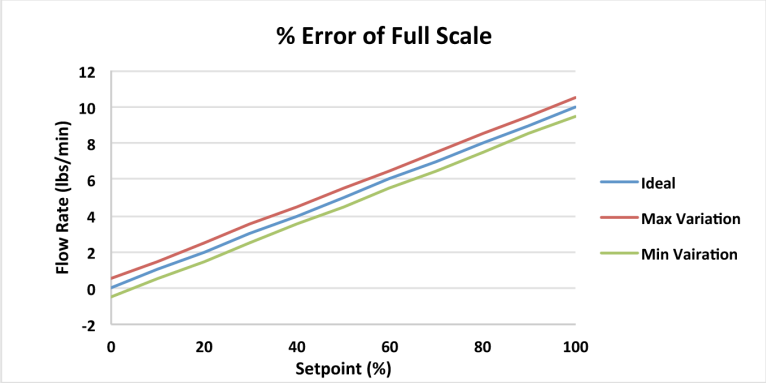
$$\pm tolerance\ band = Full\ Scale\ Flow\ Rate \times 5\%$$

$$\pm 0.5\ lbs/min = 10\ lbs/min \times 5\%$$

The actual % error of full scale at a specific Setpoint can be calculated by:

$$Error\ (\%\ FS) = \frac{Measure\ Flow\ Rate - Ideal\ Flow\ Rate}{Full\ Scale\ Range} \times 100\%$$

This tolerance band for percentage error of full scale is shown in the graph below.



The following table shows this same +/- 5% of full-scale tolerance band for the MagnaValve in this example.

Setpoint (%)	Tolerance Variation (lbs/min)	Max Flow Rate (lbs/min)	Ideal Flow Rate (lbs/min)	Min Flow Rate (lbs/min)
100	0.50	10.50	10.00	9.50
90	0.50	9.50	9.00	8.50
80	0.50	8.50	8.00	7.50
70	0.50	7.50	7.00	6.50
60	0.50	6.50	6.00	5.50
50	0.50	5.50	5.00	4.50
40	0.50	4.50	4.00	3.50
30	0.50	3.50	3.00	2.50
20	0.50	2.50	2.00	1.50
10	0.50	1.50	1.00	0.50
0	0.50	0.00	0.00	0.00

Red: Amount of variation for given Setpoint

Blue: Maximum and minimum flow rate based on the variation for given Setpoint

Green: Ideal flow rate for given Setpoint

Percentage Error of Point

Percentage Error of point can be described as the possible amount of variation at any specific Setpoint where the amount of variation is calculated using that specific Setpoint. In this example, the MagnaValve was calibrated for 10 lb/min, if the tolerance for this valve were +/-5% of point, then the tolerance band would be calculated by:

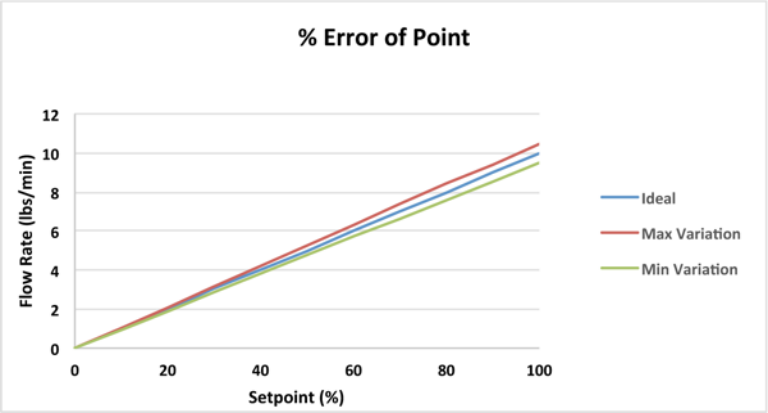
$$\pm tolerance\ for\ that\ Setpoint = \ Ideal\ Setpoint\ Flow\ Rate \times 5\%$$

$$\pm 0.35\ lbs/min = 7\ lbs/min\ (70\%\ Setpoint) \times 5\%$$

The percentage error of point at a specific Setpoint can be calculated by:

$$Error\ (\%)\ = \frac{Measure\ Flow\ Rate - Ideal\ Flow\ Rate}{Ideal\ Flow\ Rate} \times 100\%$$

This tolerance band for percentage error of point is shown in the graph below.



Setpoint (%)	Tolerance Variation (lbs/min)	Max Flow Rate (lbs/min)	Ideal Flow Rate (lbs/min)	Min Flow Rate (lbs/min)
100	0.50	10.50	10.00	9.50
90	0.45	9.45	9.00	8.55
80	0.40	8.40	8.00	7.60
70	0.35	7.35	7.00	6.65
60	0.30	6.30	6.00	5.70
50	0.25	5.25	5.00	4.75
40	0.20	4.20	4.00	3.80
30	0.15	3.15	3.00	2.85
20	0.10	2.10	2.00	1.90
10	0.05	1.05	1.00	0.95
0	0.00	0.00	0.00	0.00

Red: Amount of variation for given Setpoint

Blue: Maximum and minimum flow rate based on the variation for given Setpoint

Green: Ideal flow rate for given Setpoint

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Appendix

The 24 Vdc MagnaValves with Remote Table Select (RTS)

Like the other 24 Vdc MagnaValves, the 24 Vdc MagnaValves with RTS have five (5) internal memory tables to store calibration parameters. However, the tables in the MagnaValves with RTS can be accessed without going into a Terminal Program. These tables are accessed by applying 24 Vdc signal to the proper pins (4, 5 and 6) of the RTS connector located on the bottom of the RTS MagnaValve. Pin 3 (the green wire) of the RTS socket is connected to the MagnaValve ground system inside the MagnaValve. Three LEDs indicate the status of the three input ports (A, B and C).

Note: When calibrating multiple tables in a MagnaValve, the order in which the shot type and size is calibrated is important. For example, if the MagnaValve is being calibrated for cast steel shot and cut wire shot, the smallest cast steel shot must be calibrated first and the gain adjusted to 95% for that shot. The gain **MUST NOT** be adjusted for any other table calibration, including table calibrations for cut wire shot. If only cut wire shot will be used in the MagnaValve, the smallest cut wire shot must be calibrated first and the gain adjusted to 95% for that shot.

Order Plug/Cable Separately for RTS Connector

- 2M Length – P/N 940010
- 4M Length – P/N 940011
- 5M Length – P/N 940012

LED Status Indicators for Three Input Ports (A, B, C)

	Table 1	Table 2	Table 3	Table 4	Table 5
A LED (Pin 4)	● ● ●		● ● ●		● ● ●
B LED (Pin 5)		● ● ●	● ● ●		
C LED (Pin 6)				● ● ●	● ● ●

● No voltage applied
● 24 Vdc applied
● Error - RTS function may be disabled

Wiring for 24 Vdc MagnaValve with RTS

Pin Number	Color	Function
1	Red/White	N/C
2	Red	N/C
3	Green	Ground
4	Red/Yellow	A
5	Red/Black	B
6	Red/Blue	C

Wiring Diagram