

Velocity dependent Correction Factors (VCF)

One of the fundamental installation issues with any insertion flow element or transmitter is the proper setup of the correction factors between point velocity measurements and the process flow (integration of many equal area point velocity measurements). Due to viscous drag, the velocity tends to be highest in the center of the process duct, stack or pipe for long runs. Near corners, valves or line size changes there will be other velocity profile issues that can also be adjusted for using this method if they are repeatable.

There are two common methods used to establish correction factors:

- Theoretical estimate based on the duct size, gas type etc. (with long straight runs can be +/- 5 % accurate)
- Field calibration (traverse, tracer gas etc.), can be +/- 5%, +/- 2.5% respectively even with non-ideal flow profiles.

Once the velocity dependent correction factors have been established, there are up to 8 data sets or points (7 for 155 and MFT) that can be programmed to multiply against the raw velocity average to determine the corrected velocity average. The MFT line, MFT B-Series and 155 Flow Computers all share similar algorithms for correction factors. To explain how this works, we have five cases to look at.

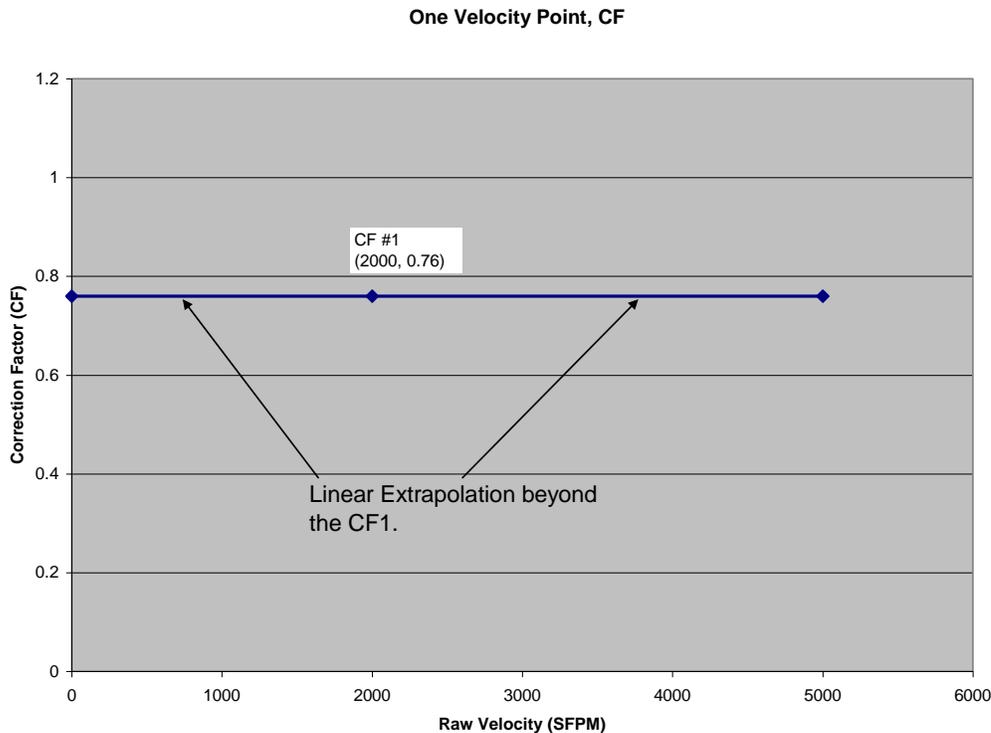


Figure AK-1 Correction factor function with one data point.

In the case of one data point we see this correction factor applies to all velocities above and below the value entered. It therefore does not matter what velocity is used to enter the correction factor.

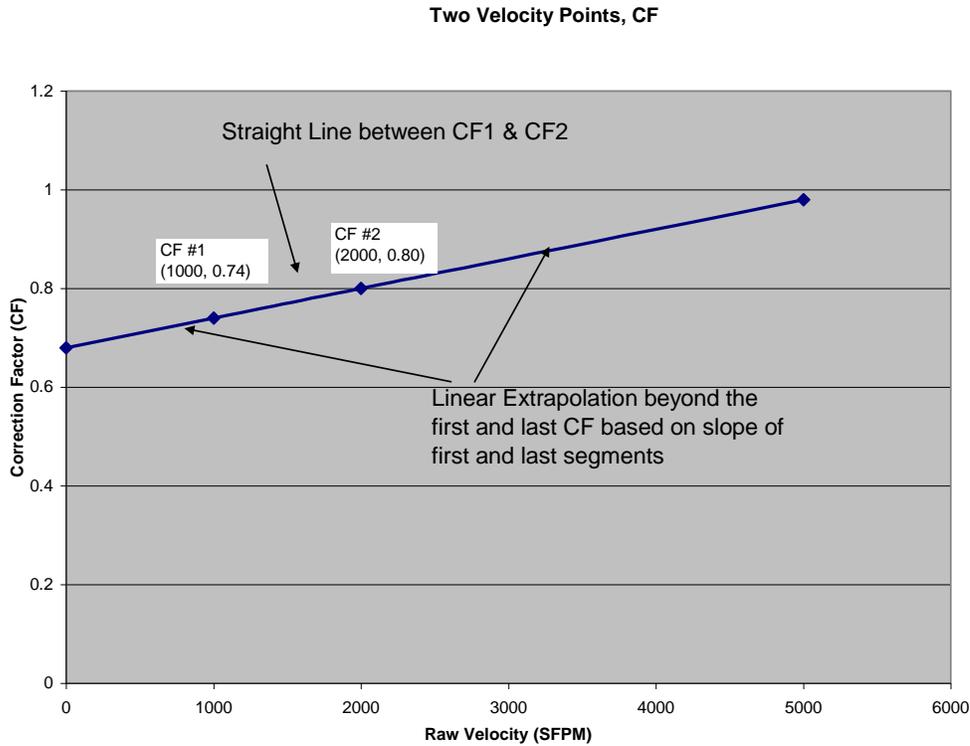


Figure AK-2. Correction Factor function with two data points.

When two correction factors are entered, a simple straight line is used between these points which also applies above and below the values entered as shown in Figure AK-2.

When three correction factors are entered, there are two straight lines used. The first line is based on CF1 and CF2 and applies between these points and at velocities below this. The second line is based on CF2 and CF3 and all points above these velocities as shown in Figure AK-3.

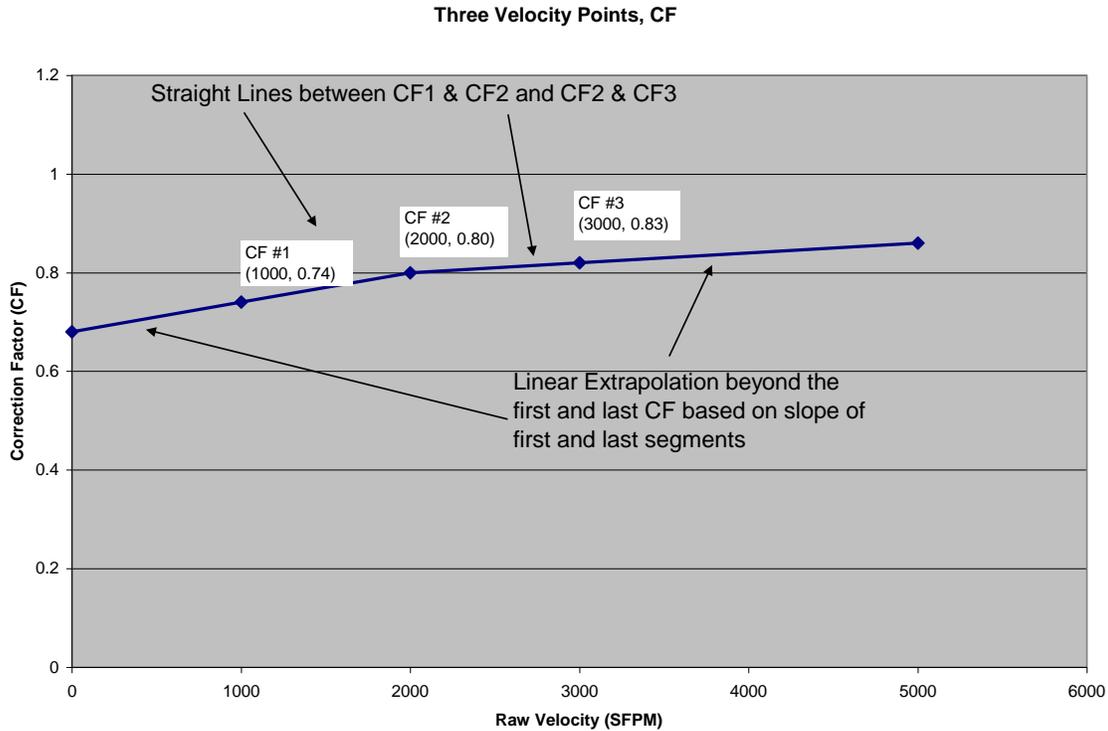


Figure AK-3. Correction Factor function with three data points.

Warning

If points are placed too close in velocity to each other with CF that vary too much, you will get very large swings in the CF, especially with velocities outside or beyond lower and upper end points.

Recommendations

It is recommended that all correction factors be inspected in a spreadsheet for their smoothness before programming into a Kurz flow meter or flow computer.

Alternately, set the first CF at 0 velocity and the last at the Max. velocity so you are never extrapolating from the slope of the first and last segments. This ensures the CF is a reasonable value over the velocity range of interest.

If four points or more are used, the correction factors for the center points are second order smooth curves in the 155 flow computer. The first and last segments are still straight lines as well as velocities above and below the first and last points as shown in Figures AK-4 and AK-5. The MFT and MFT B-Series use the linear line segment method described for three data points even when four or more points are entered.

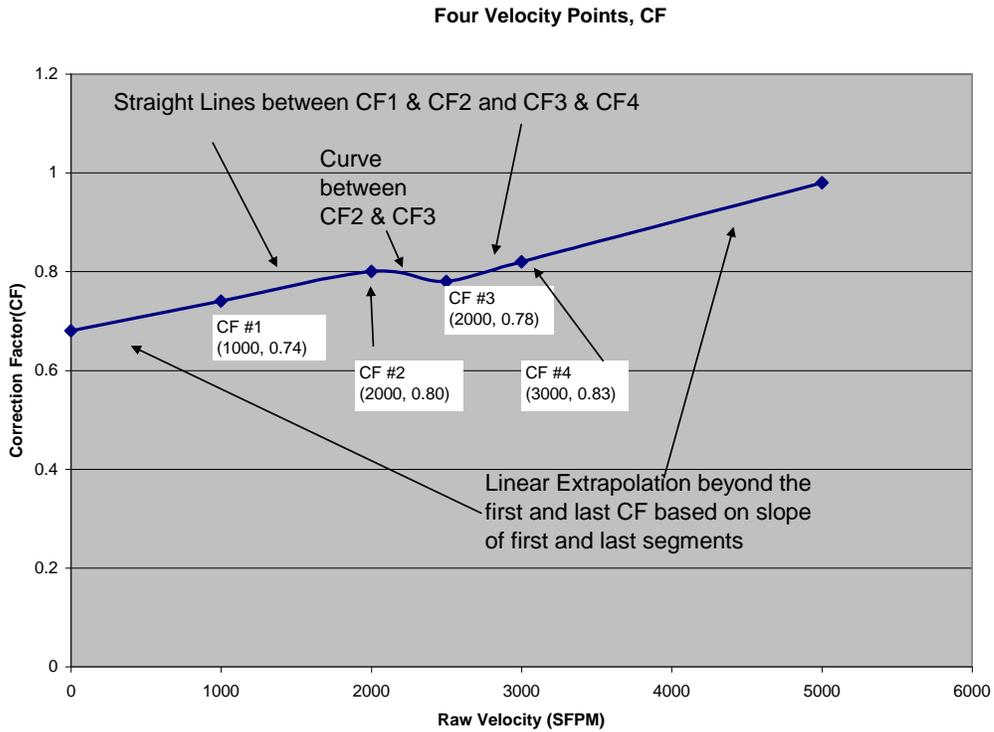


Figure AK-4. Correction Factor function with four data points. 155 only.

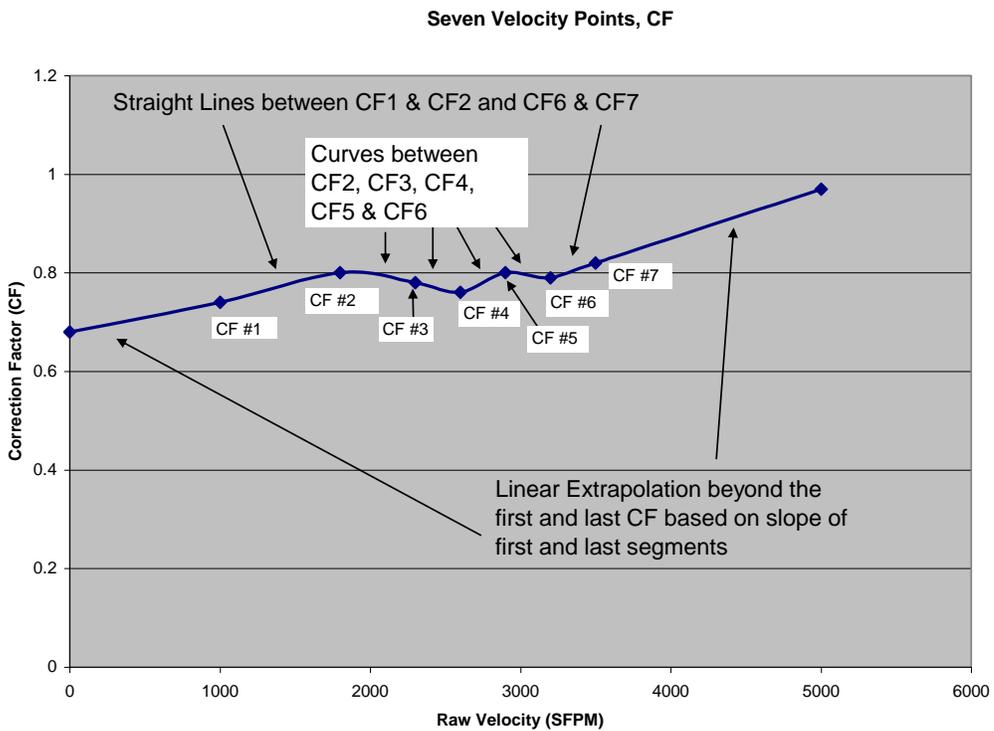


Figure AK-5. Correction Factor function with five data points. 155 only

User Menus for Variable CF

Before looking at the meter's onboard menus to enter the correction factor data, we need to understand some nomenclature first.

Nomenclature

The variable correction factor examples shown in Figures AK-1 to AK-5 have a CF at velocity X. However, the flow meter's onboard menus to enter this data are based on two velocity numbers, the reference velocity (R) at the observed velocity data (D) as shown in Table AK-1.

Table AK-1 Comparison of Reference velocity (**R or V_{rm}**), Observed velocity Data (**D or V_{ds}**) and computed **CF**

Data Set #	R (MFT & MFT B) V _{rm} (155)	D (MFT & MFT B) V _{ds} (155)	CF
1	740	1000	0.74
2	1440	1800	0.8
3	1794	2300	0.78
4	1976	2600	0.76
5	2320	2900	0.8
6	2528	3200	0.79
7	2870	3500	0.82

Collecting the data then graphing it in a spreadsheet requires making a new column as shown above, $CF = R/D$. Then the graph of CF vs. D can be drawn to ensure it is smooth and extrapolates to lower and higher velocities as needed.

The 155 multipoint flow computer uses indicated velocity data for each input channel associated with a meter as well as the process average velocity. The extra data is used to make the best correction factor estimate possible if a sensor is "kicked out" or removed from the average. Table AK-2 compares this nomenclature between the single point and multipoint meters.

Table AK-2. Three velocity data set comparisons of the data needed for a four sensor 155 multipoint system and a single point MFT or MFT B meter.

	Velocity Data Set #	Reference Velocity Average	Indicated Sensor Velocity Data
155 * CF type =CCF	1	Vrm1	Vds1 CH A Vds1 CH B Vds1 CH C Vds1 CH D
	2	Vrm2	Vds2 CH A Vds2 CH B Vds2 CH C Vds2 CH D
	3	Vrm3	Vds3 CH A Vds3 CH B Vds3 CH C Vds3 CH D
MFT series 454FT, 504FT, 534FT K-BAR-2000 2440	1	R1	D1
	2	R2	D2
	3	R3	D3
MFT B-Series 454FTB 504FTB 534FTB K-BAR-2000B	1	R1	D1
	2	R2	D2
	3	R3	D3

* The 155 supports two formats of CF, one called CCF and the other VCF. The recommended method with the 155 is CCF and it works as shown in Table AK-2 and matches the MFT line nomenclature as shown. The VCF type is not recommended with the multipoint 155 systems and is not described here.

Correction Factor Menus

The Correction Factor (CF) menus are found under *Program Mode*. The 155 flow computer menus are found in the [360204-6.81](#) summary guide.

The 155 supports both a “BIAS” correction factor which is a velocity independent correction factor, just like having one data set and the multiple velocity dependent correction factors.

In addition to the velocity independent and the multiple velocity dependent correction factors, the MFT line and MFT B-Series also have a sensor blockage correction factor SBCF which is based on the probe support diameter, insertion depth and duct area. It is a number < 1.0 that accounts for the area blockage caused by the probe support and sensor window. The SBCF is automatically recalculated whenever the user changes the insertion depth or duct (flow) area.

MFT B-Series Meter Correction Factors

Once the field calibration process ([CAL-016](#)) is complete and the correction factors are reviewed on a spreadsheet, it is safe to enter this data into the flow meter. Then the indicated flow reading will match the reference method flow data resulting in the best absolute accuracy.

Velocity Independent Correction Factor

The Field Calibration Correction Factor is a velocity independent correction factor which is useful to “tune” the meter without having to re-enter a whole set of correction factors from a field calibration. The Flow Correction Factor Setup is available in *Program Mode*. Enter *Program Mode*, press **P**, the **654321** access code, and **E**. Press **2** to invoke the *Quick Jump* option entry method and select **Option #3** for the Flow Calibration CF Setup menu. If the meter is an Insertion Type flow meter, the meter will display the Sensor Blockage Correction Factor. Press **P** to advance to the next setup screen.

SENS BLOCKAGE CF
IS 0.99947

The meter prompts for the Field Calibration Correction Factor as follows

FIELD CALIB CF
>1.000000

Use the numeric keys and the decimal key to enter a different correction factor and press **E** to accept the new value or press **P** to skip the entry and keep the current value. The Field Calibration CF should be a value between 0.01 to 10.0. The factory default is 1.00.

Press **H** to return to the *Program Mode* option entry screen.

Velocity Dependent Correction Factor

The velocity dependent correction factors are entered in *Program Mode*. Enter *Program Mode*, press **P**, the **654321** access code, and **E**. Press **2** to invoke the *Quick Jump* option entry method and select **Option #15** for the Variable Flow Correction Factor setup menu. The meter first prompts for the number of correction factor data sets to be used

```
ENTER # OF FLOW
DATA SETS >1
```

Use the numeric keys to type the number of data sets and press **E** to accept the entry. Again, this is the number of data sets to be used for velocity or flow rate dependent correction factors. The next prompt asks for the data set that will be entered.

```
ENTER FLOW DATA
SET # >1
```

Use the numeric keys to type the data set number that is being entered. The data set number refers to the pair of reference vs observed flow/velocity data. For each data set, a reference flow rate (in-line meters) or velocity (insertion meters) - Rx and an observed flow rate or velocity – Dx is entered.

The meter first prompts for the reference data

```
REF VALUE R1
>X.XXXX FUNIT
```

Use the numeric keys and decimal keys to enter the reference velocity or flow rate and press **E** to accept the entry; or press **P** to skip over the value.

The meter next prompts for the observed data

```
TEST DATA D1
>Y.YYYY FUNIT
```

Use the numeric keys and decimal keys to enter the observed velocity or flow rate and press **E** to accept the entry; or press **P** to skip over the value without making any changes. The units of the reference and observed velocity/flow (shown as FUNIT in the examples above) will be in the same units as the meter's velocity/flow variable. The meter will repeat the sequence of prompts until the user has loaded the correction factor table for all data sets. After all the data sets have been entered, the meter exits from the Variable Flow Correction Factor setup and returns to the *Program Mode* option entry screen.

All the correction factors discussed above are multiplied to calculate a Total Correction Factor.

$$\text{Total CF} = \text{SBCF} \times \text{BCF} \times \text{VCF}.$$