Technical Data Sheet
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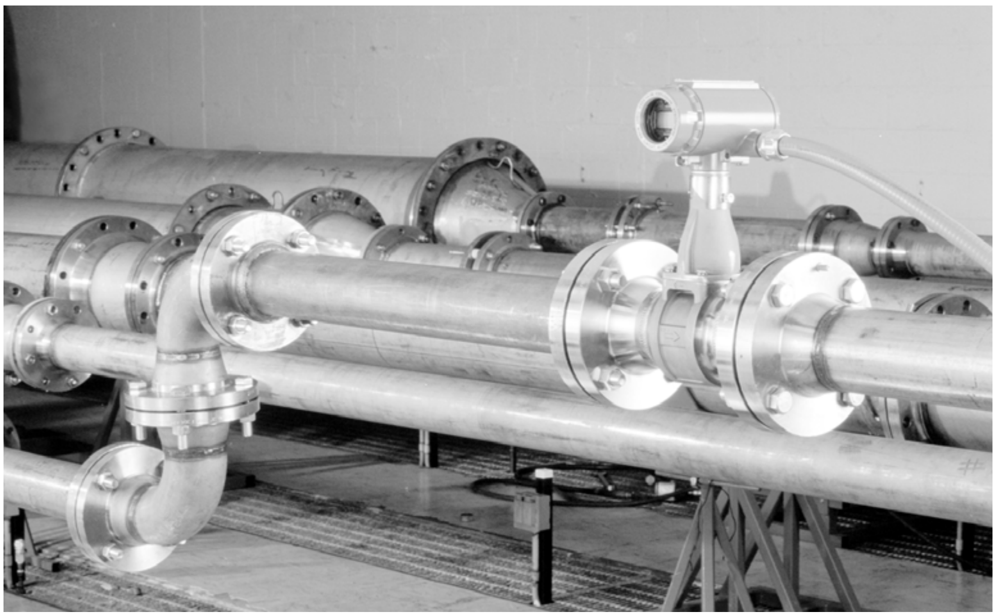
Rosemount™ 8800 Vortex Installation Effects



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Process Management

1.1 Introduction

The Rosemount 8800 Vortex Meter provides methods for maintaining accuracy in less than ideal installations.

In designing the 8800, Rosemount tested the meter for three separate types of installation effects:

- Process fluid temperature variation
- Process piping inside diameter
- Upstream and downstream disturbances

As a result of this testing, compensation factors are included in the vortex meter software; this allows the output of the vortex meter to be adjusted for the actual process temperature and process piping being used.

Data is presented in this paper to demonstrate the effectiveness of the design in limiting the errors resulting from piping disturbances. For upstream disturbances caused by pipe elbows, contractions, expansions, etc., Rosemount has conducted extensive research in a flow lab to determine the effect that these have on the meter output. These tests are the basis for the recommended 35 upstream piping diameters. While this is optimal, it is not always possible in the real world of plant design and layout. Therefore, the data presented in this paper outlines the effects of different upstream and downstream piping conditions on the vortex meter.

1.1.1 Temperature effects on K-factor

The vortex meter is fundamentally a velocity measuring device. As fluid flows past the shedder bar, vortices are shed in direct proportion to the fluid velocity. If the process temperature is different than the reference calibration temperature, the meter bore diameter will change slightly. As a result, the velocity across the shedder bar will also change slightly. For example; an elevated process temperature will cause an increase in the bore diameter, which in turn will cause a decrease in the velocity across the shedder bar.

Using the *Reference K-factor* and the value for *Process Temperature* input by the user, the Rosemount 8800 automatically calculates for the effect of temperature on the meter by creating what is called the *Compensated K-factor*. The *Compensated K-factor* is then used as the basis for all flow calculations.

1.1.2 Pipe ID effects on K-factor

All Rosemount 8800 Vortex Meters are calibrated in schedule 40 pipe. From extensive testing done in piping with different inside diameters/schedules, Rosemount has observed there is a small K-factor shift for changes in process pipe ID (inside diameter). This is due to the slight change in velocity at the inlet to the meter.

These changes have been programmed in to the 8800 electronics and will be corrected for automatically when the user supplied pipe ID is other than schedule 40.

1.1.3 Upstream and downstream piping configurations

The number of possible upstream and downstream piping configurations is infinite. Therefore, it is not possible to have software automatically calculate a correction factor for changes in upstream piping. Fortunately, in almost all cases, elbows, reducers, etc. cause less than a 0.5% shift in the meter output. In many cases, this small effect is not a large enough shift to cause the reading to be outside of the accuracy specification of the meter.

The shifts caused by upstream piping configurations are basically due to the changes in the inlet velocity profile caused by upstream disturbances. For example, as a fluid flows around an elbow, a swirl component is added to the flow. Because the factory calibration is done in a fully-developed pipe flow, the swirl component caused by the elbow will cause a shift in the vortex meter output. Given a long enough distance between an elbow and the meter, the viscous forces in the fluid will overcome the inertia of the swirl and cause the velocity profile to become fully-developed. There rarely is sufficient length in actual process piping installations for this to occur. Even though the flow profile may not be fully-developed, testing indicates that the Rosemount vortex meter can be located within 35 pipe diameters of the elbow with minimal effect on the accuracy or repeatability of the meter.

Although the upstream disturbance may cause a shift in the K-factor, the repeatability of the vortex meter is normally not affected. For example, a meter 20 pipe diameters downstream of a double elbow will be as repeatable as a meter in a straight pipe. Testing also indicates that while the K-factor is affected by upstream piping, the linearity of the meter remains within design specifications.

In many applications, this means that no adjustment for piping configuration will be necessary — even when the minimum recommended installation lengths of upstream and downstream piping cannot be used.

On the following pages are drawings illustrating various installation configurations. Extensive testing has been performed in a flow lab with these specific configurations. The results of those tests are shown as a series of graphs indicating the shift in the mean K-factor for a vortex meter placed downstream of a flow disturbance.

1.1.4 In plane versus out of plane

In the graphics, the terms *in plane* and *out-of-plane* are used. A butterfly valve and a vortex meter are considered to be *in plane* when the shaft of the valve and the shedder bar of the vortex meter are aligned (e.g. both the shaft and the shedder bar are vertical.)

- In reference to Figure 1-17A, a butterfly valve and a vortex meter are considered to be *in plane* when the shaft of the valve and the shedder bar of the vortex meter are aligned (e.g. both the shaft and the shedder bar are vertical).
- In reference to Figure 1-7A, the elbow is considered *in plane*. Referring to Figure 1-7B, the elbow is considered *out of plane* because the shedder bar in the vortex meter is rotated 90°.

Similarly, in Figure 1-11 on page 11, two 90° elbows (which themselves are in a common plane) are shown; their plane is considered to be *in plane* with the vortex meter. Figure 1-13 on page 12 contains data from two 90° elbows which do not have a common plane. The plane of the elbows entering and exiting the vortex meter is not aligned with the shedder bar of the vortex meter, therefore this configuration is considered *out-of-plane*.

1.2 Correcting the output of the vortex meter

Correction factors can entered into the vortex meter transmitter using AMS™ Device Manager, ProLink™ III v3 or a 475 or similar HART® Field Communicator.

For all Fieldbus devices and devices with HART software revisions 5.2.5 and earlier, the K-factor can be adjusted using the *Installation Effect* command. This command will adjust the compensated K-factor to account for any correction needed. The correction will be entered as a percentage of the K-factor shift. The possible range of the shift is +1.5% to -1.5%.

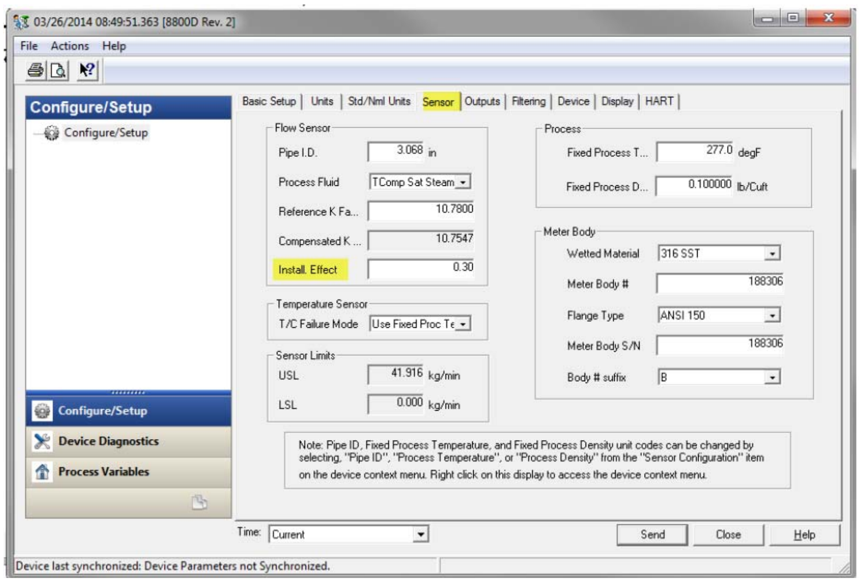
For devices with HART revision 5.3.1 or 7.2.1 and later, the correction factor will be entered using the Meter Factor command. This command works in a similar way to the Installation Effect command but has an inverse relationship to k-factor shift and an enter-able range of 0.8 to 1.2. Entering a value of 0.8 represents a +20% shift in k-factor, a value of 1.0 represents a 0% shift in k-factor, and a value of 1.2 represents a -20% shift in k-factor.

1.2.1 Fieldbus and HART software revisions 5.2.5 or earlier

Using AMS Device Manager

Under the *Sensor* tab, enter the correction in the *Install Effect* field. See Figure 1-1.

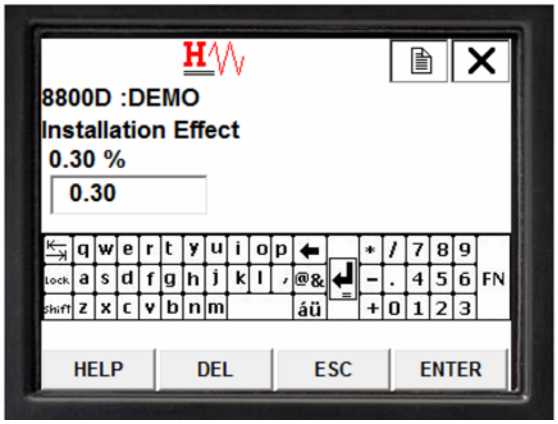
Figure 1-1. Using AMS Device Manager



Using a 475 HART Field Communicator

Go to **Manual Setup > Sensor > Process > Installation Effect** and then enter the correction number in the field. See Figure 1-2.

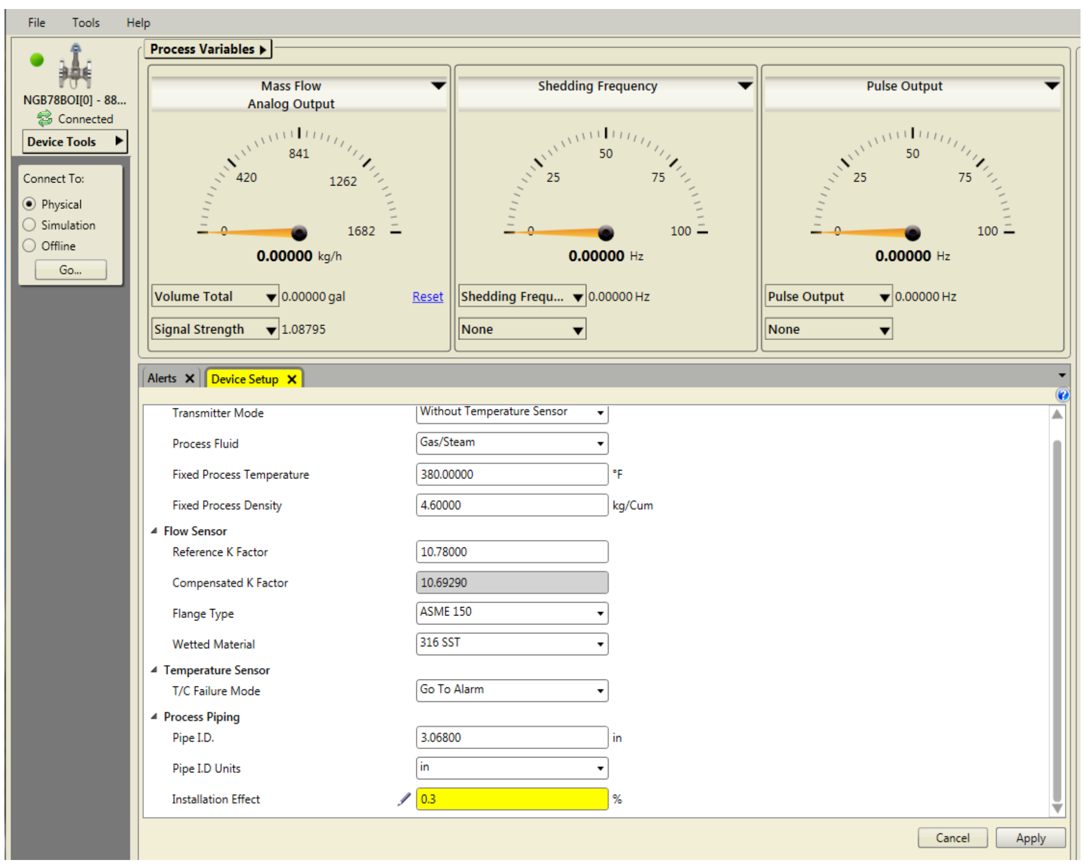
Figure 1-2. Using a 475 HART Field Communicator



Using ProLink III v3

To enter the Installation Effect, select **Device Tools > Configuration > Device Setup > Installation Effect.** See Figure 1-3.

Figure 1-3. Using ProLink v3

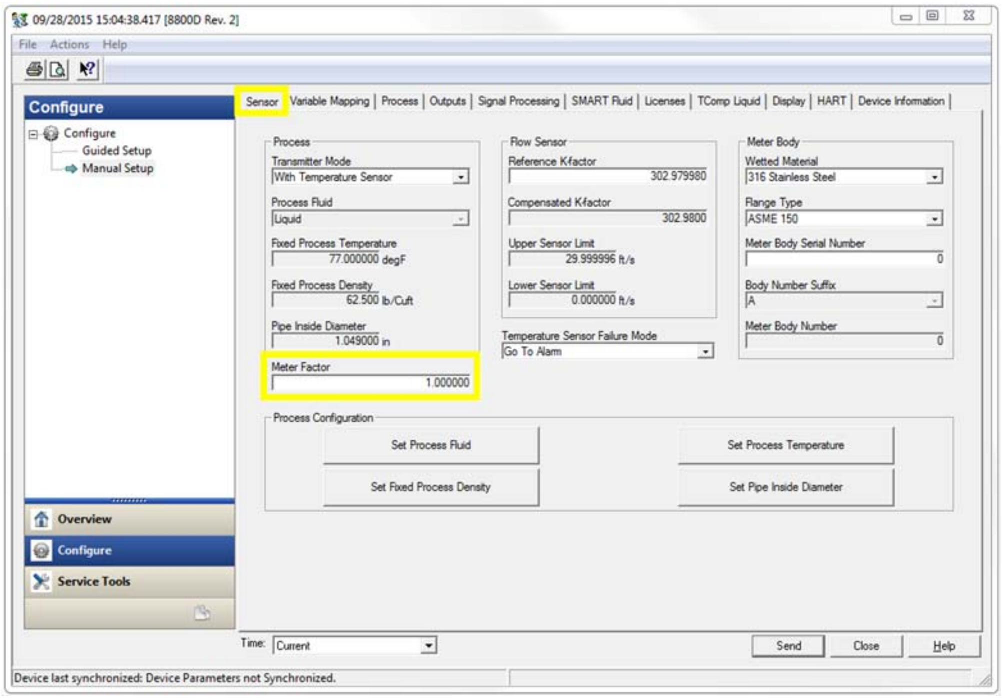


1.2.2 HART software revisions 5.3.1 or 7.2.1 and later

Using AMS Device Manager

Under the Sensor tab, enter the correction in the Meter Factor field. See Figure 1-4.

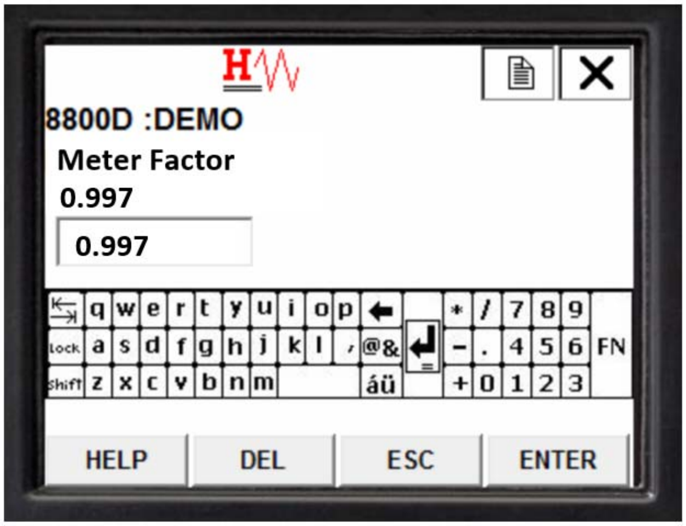
Figure 1-4. Using AMS Device Manager



Using a 475 HART Field Communicator

Go to **Manual Setup > Sensor > Process > Meter Factor** and then enter the correction number in the field. See Figure 1-5.

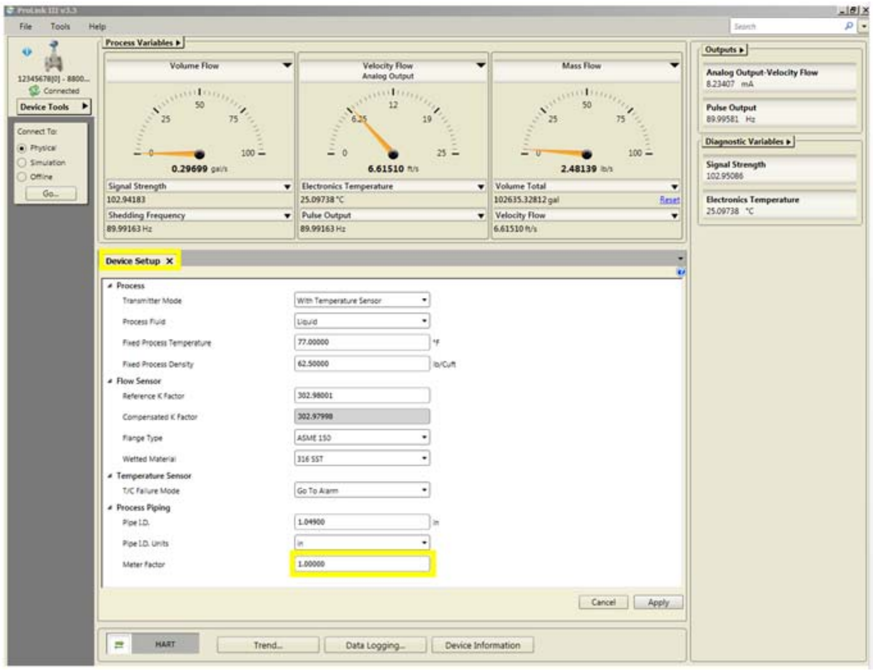
Figure 1-5. Using a 475 HART Field Communicator



Using ProLink III v3

To enter the Installation Effect, select **Device Tools > Configuration > Device Setup > Meter Factor**. See Figure 1-6.

Figure 1-6. Using ProLink III v3



1.2.3 Correction factor examples

Example 1: The 8800 Vortex Meter is installed 15 pipe diameters downstream from a single 90° elbow, with the shedder bar in plane. Looking at Single Elbow Graph and following the *IN PLANE* line, the K-factor shift would be +0.3% at 15 pipe ID.

To adjust the K-factor to correct for this shift, enter +0.3% into the *Installation Effect* field or 0.997 for devices utilizing Meter Factor.

Example 2: The 8800 Vortex Meter is installed 10 pipe diameters downstream from a butterfly valve, with the shedder bar out of plane. Looking at Butterfly Graph and following the *OUT OF PLANE* line, the K-factor shift would be -0.1% at 10 pipe ID.

To adjust the K-factor to correct for this shift, enter -0.1% into the *Installation Effect* field or 1.001 for devices utilizing Meter Factor.

Figure 1-7. Single Elbow

A. In Plane
B. Out of Plane

Figure 1-8. Single Elbow Graph

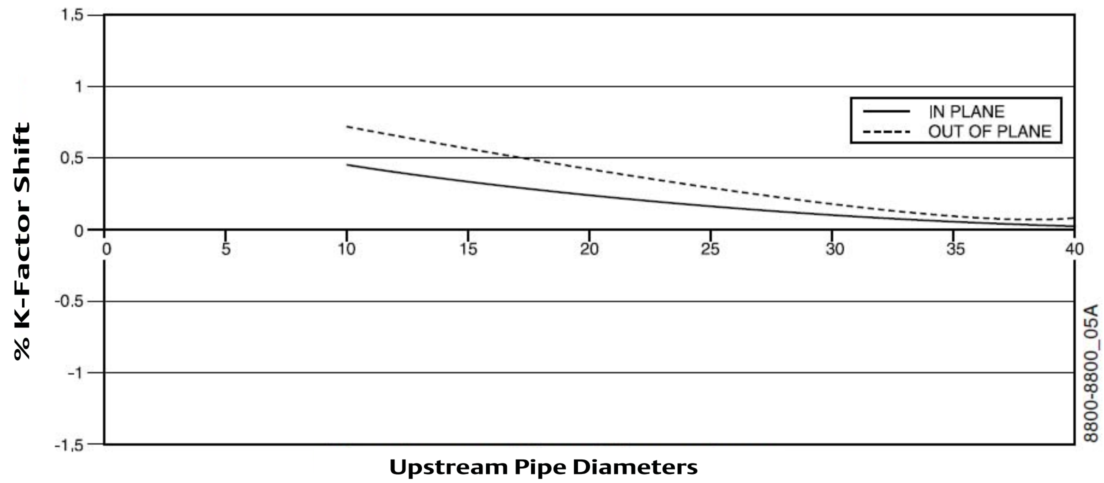


Figure 1-9. Pipe Expansion

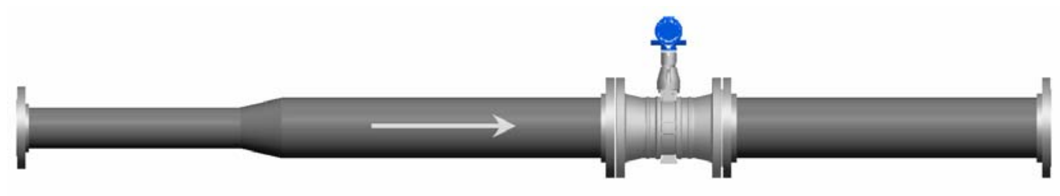
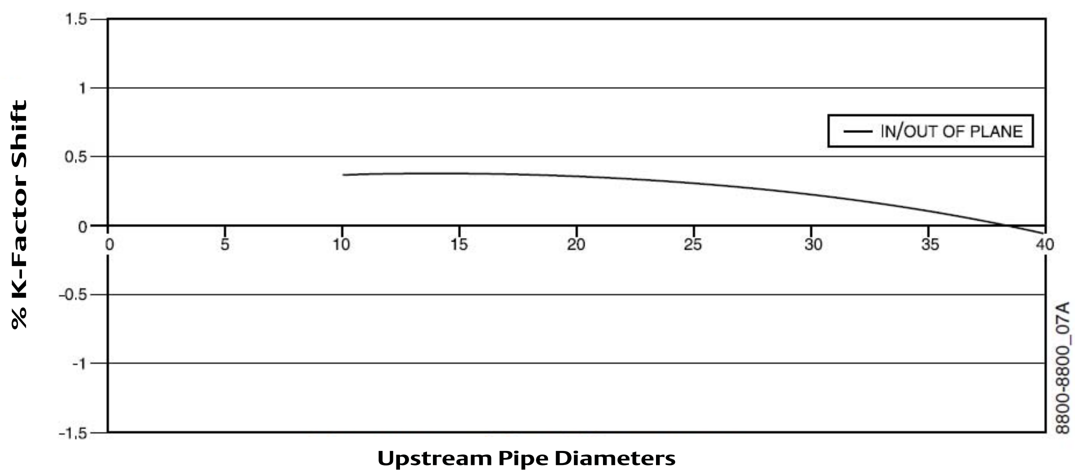


Figure 1-10. Pipe Expansion Graph



K-Factor shift based on data collected with concentric pipe expander.

Figure 1-11. Double Elbow

A. In Plane
B. Out of Plane

Figure 1-12. Double Elbows - Same Plane Graph

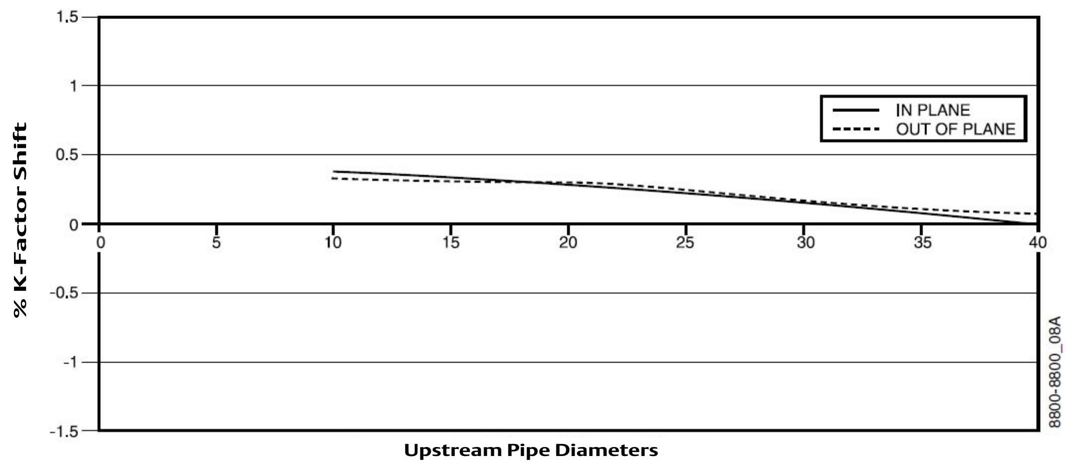
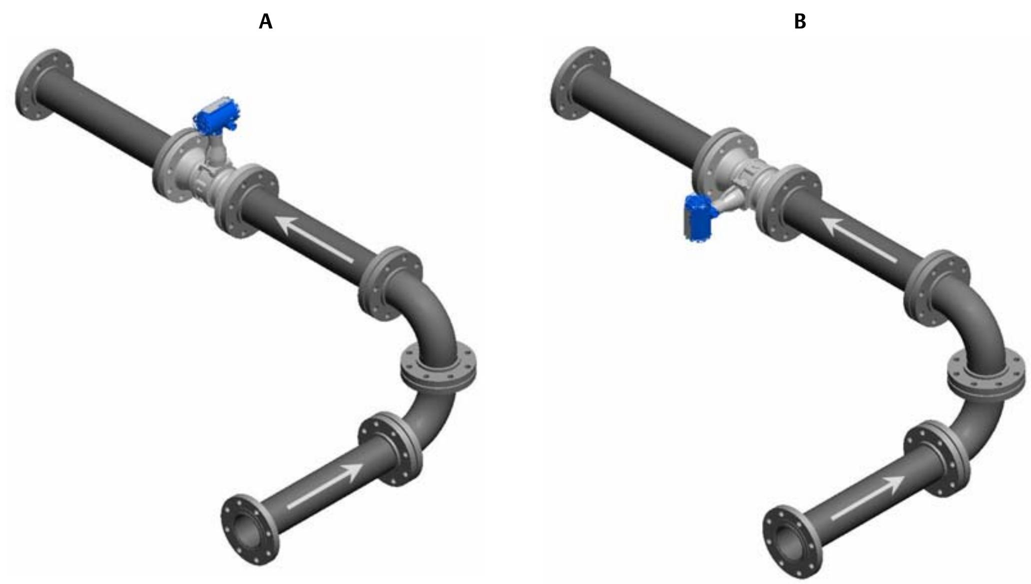


Figure 1-13. Double Elbow Different Plane



A. In Plane

B. Out of Plane

Figure 1-14. Double Elbows - Different Plane Graph

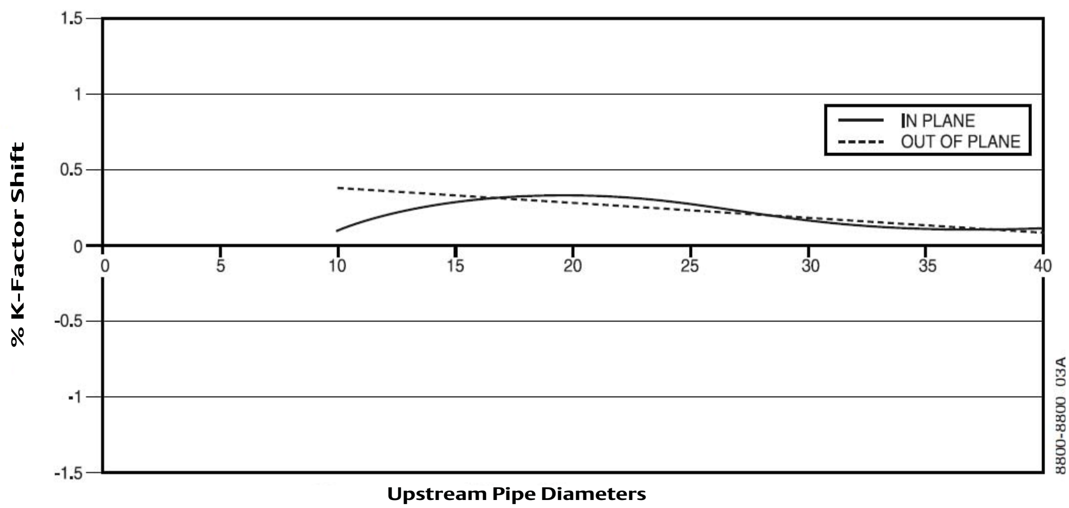


Figure 1-15. Reducer

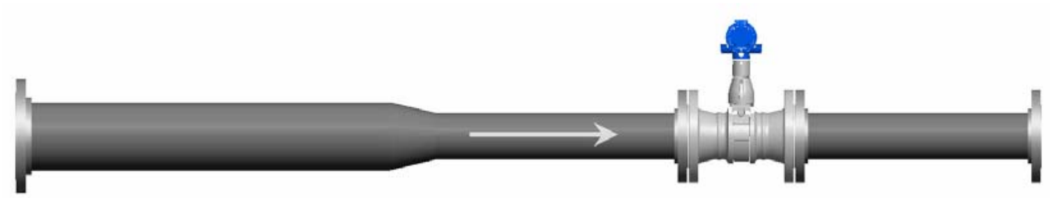
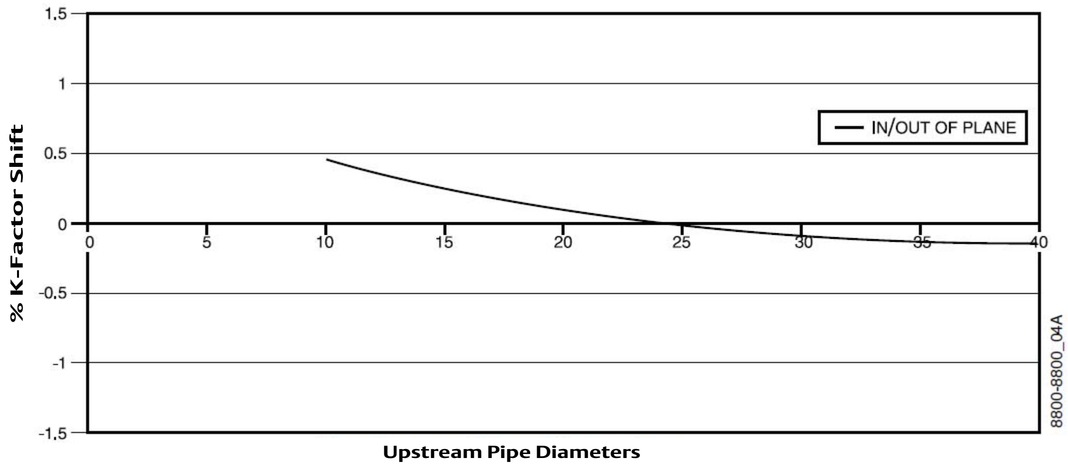


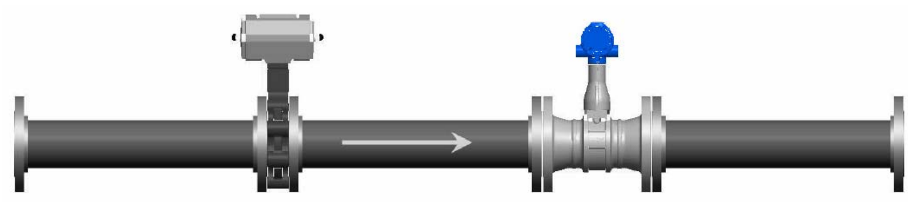
Figure 1-16. Reducer Graph



K-Factor shift based on data collected with concentric pipe reducers.

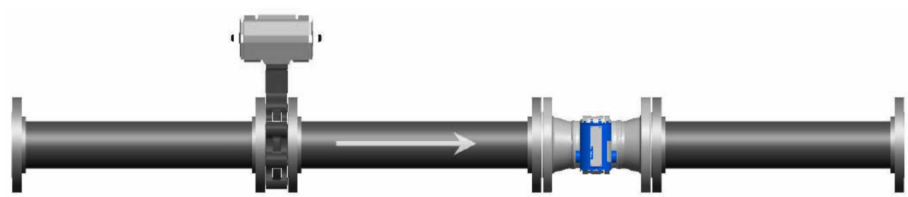
Figure 1-17. Butterfly Valve

A



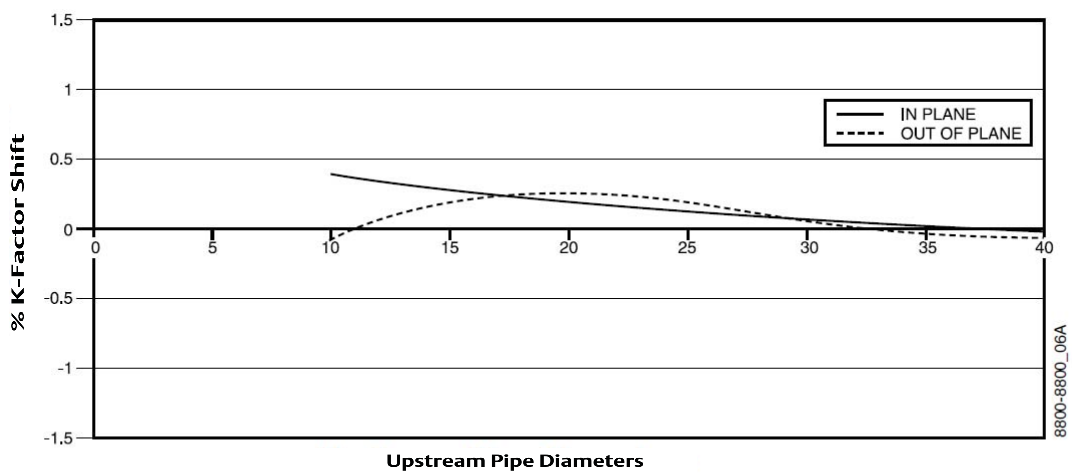
A. In Plane

B

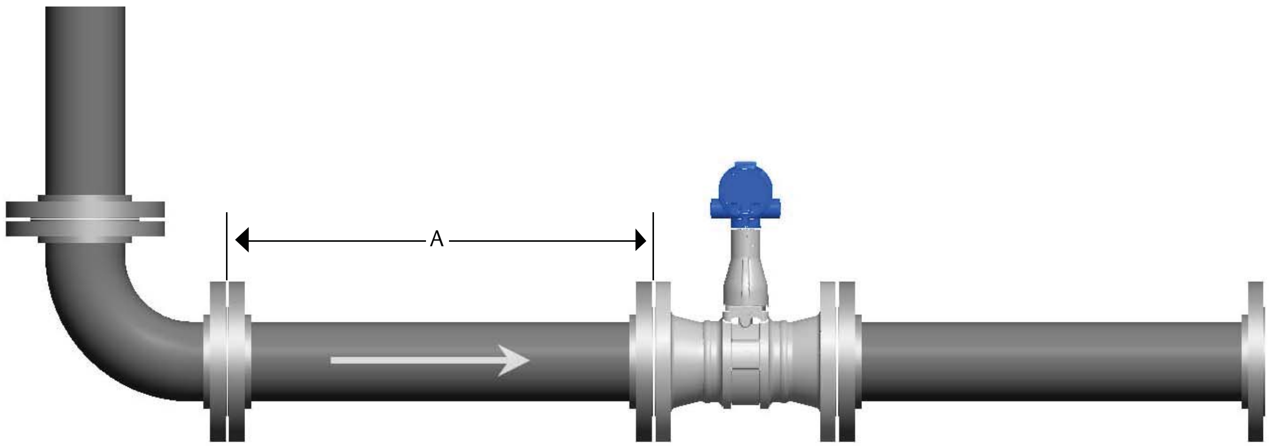


B. Out of Plane

Figure 1-18. Butterfly Graph



2.1 Calculating upstream and downstream pipe diameters



A. Pipe ID's calculated face to face

Note
When using a reducer Vortex, pipe ID's are calculated using the process pipe ID not the meter body ID.

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