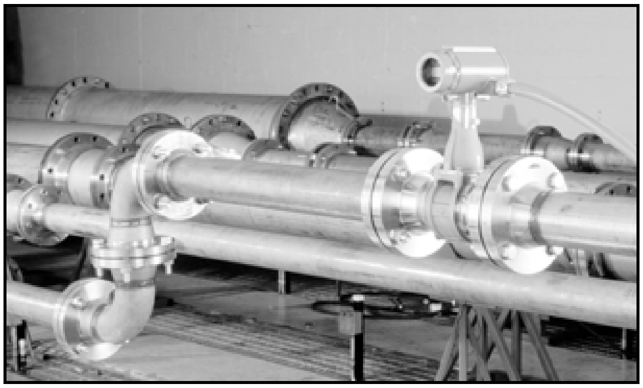
Rosemount 8800 Vortex Installation Effects



One of the perceived limitations of vortex meters is that they are highly sensitive to installation effects. Since it is true that the conditions in a plant environment may be quite different than the conditions under which the vortex meter is calibrated, some meters may be adversely affected by the installation conditions. The Rosemount® 8800 Vortex Flowmeter is designed to compensate for or limit the effects encountered in actual installations.

In designing the 8800, Emerson tested the meter for three separate types of installation effects: process fluid temperature variation, process piping inside diameter, and upstream and downstream disturbances. As a result of this testing, compensation factors are included in the vortex meter software; which allows the output of the vortex meter to be adjusted to compensate 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., Emerson has conducted extensive research in the flow lab to determine the effect that these have on the meter output. These tests are the basis for the recommended 35D upstream piping diameter. 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.

Temperature Effects

The vortex meter is a velocity measuring device. As fluid flows past the shedder bar, vortices are shed in direct proportion to the passing velocity. If the temperature of the process is different than the reference calibration temperature, the meter bore diameter will change. This causes the velocity past the shedder bar to change. An increase in the temperature causes an increase in the bore diameter, which causes a slight decrease in the velocity past the shedder bar. The 8800 automatically calculates the effect of temperature on the mean K-factor of the meter for whatever process temperature has been input by the user.

Pipe ID Effects

In a similar manner, the 8800 will automatically correct for the user defined inside pipe diameter. From testing done in pipes with different inside diameters, Emerson has established that there is a small K-factor shift for changes in process pipe ID. This is because different pipe inside diameters change the inlet velocity profile that the meter sees. These shifts have been programmed into the 8800 and are automatically corrected for based on the pipe diameter that is input by the user.

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 what is 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.

In the Emerson R&D flow lab, several common pipe configurations have been set up. The 8800 has been tested at various lengths downstream of these configurations and the resulting mean K-factor shifts have been determined. These graphs are shown on the following pages.

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 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. However, the user may adjust the meter K-factor directly or use the special units features to make an adjustment to the output of the meter to compensate for these small piping effects.

On the following pages are pictures that show examples of the installation configurations that were done in the Emerson flow lab. 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.

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.) Referring to the photo of a single elbow installation shown in Figure 1 on page 4, the elbow is considered to be “in plane.” Similarly, in Figure 4 on page 5, 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 6 on page 5 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.”

CORRECTING THE OUTPUT OF THE VORTEX METER

The flow disturbance data can be used to correct the output of the vortex meter in the following ways:

1. The K-factor can be adjusted using the *Installation Effect* command. This command will adjust the compensated K-factor to account for the correction. The correction can be entered as a percentage of the K-factor shift. The range of this factor is +1.5% to -1.5%.

NOTE
If this command is not available (early software revisions of the 8800), please refer to step 2 or step 3.

As an example from Figure 2 on page Flow-4, a three-inch vortex meter installed 15 pipe I.D.s downstream from a single elbow, with the shedder bar in plane, the K-factor shift would be +0.3%.

To adjust the K-factor to correct for this shift, insert the +0.3% into the Installation Effect command on the 275. The compensated K-factor will then show the correction.

2. The K-factor can be adjusted by the percentage shift in the K-factor.

Follow the example above to adjust the K-factor to correct for this shift. Since the shift is +0.3%, multiply the reference K-factor as shown on the nameplate by 1.003. Then enter this as the new reference K-factor. A typical three-inch meter reference K-factor would be 10.79 p/gal.

Using the above example, the new K-factor would be 10.82 p/gal.

Likewise, for a butterfly valve (Figure 9) out of plane at 10 pipe diameters, there is a K-factor shift of -0.1%. To adjust the K-factor to correct for the shift, multiply the reference K-factor as shown on the nameplate by 0.999 and enter the new K-factor.

3. Special Units can be configured using the conversion number to reflect the shift in the K-factor.

To configure Special units with a 275 HART Communicator, change the PV units to special. Follow the single elbow example above (+0.3% shift in K-factor) and multiply the conversion number by 1.003 and enter this new number. A three-inch meter configured 0 to 300 gallons per minute would be configured in special units as Gal/M, with a conversion number of 1.003.

FIGURE 1. Single Elbow in Plane

FIGURE 2. Single Elbow Graph

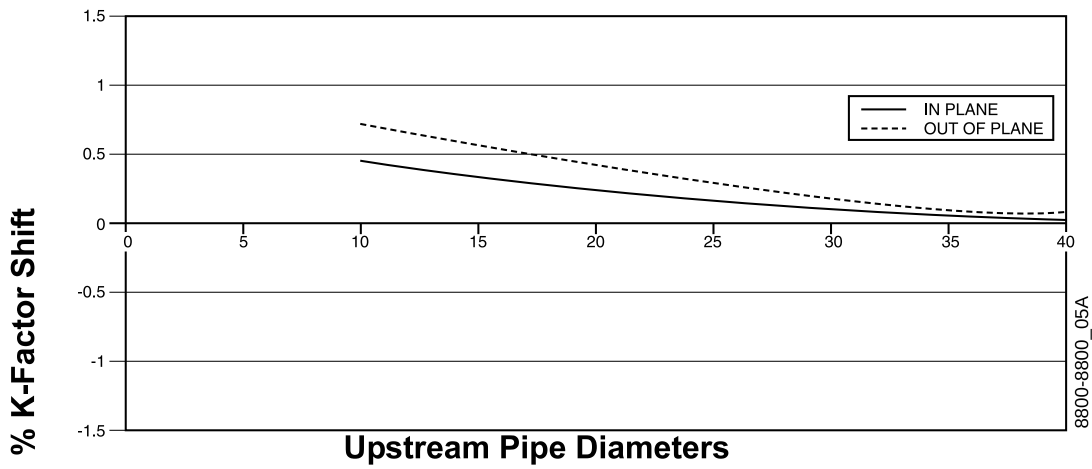


FIGURE 3. Expansion Graph

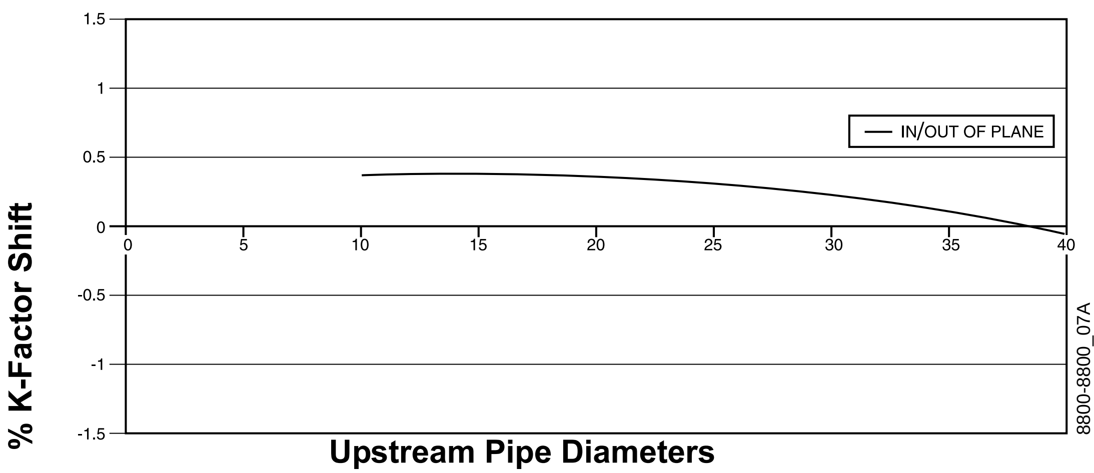


FIGURE 4. Double Elbow in Plane

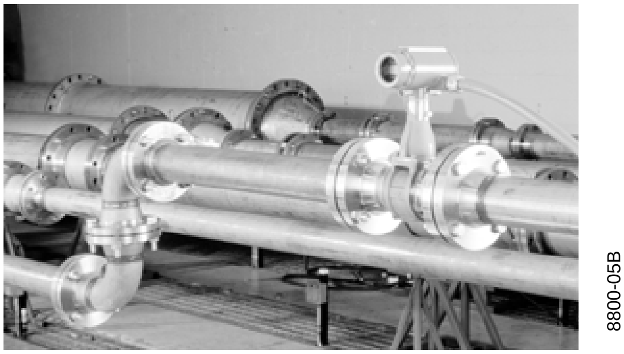


FIGURE 5. Double Elbows - Same Plane Graph

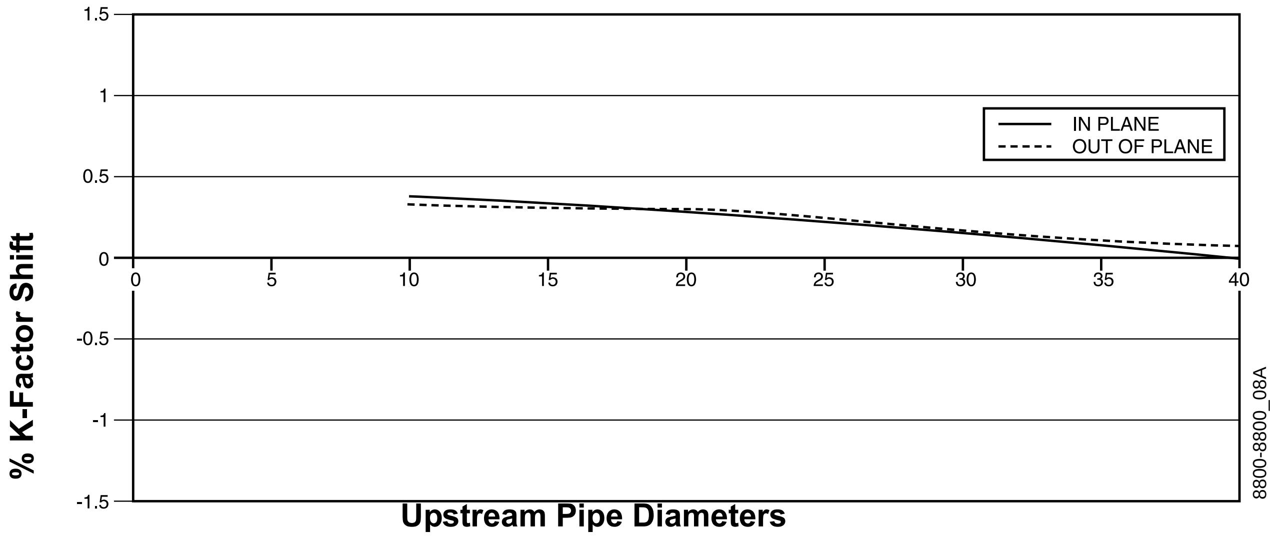


FIGURE 6. Double Elbows - Different Plane Graph

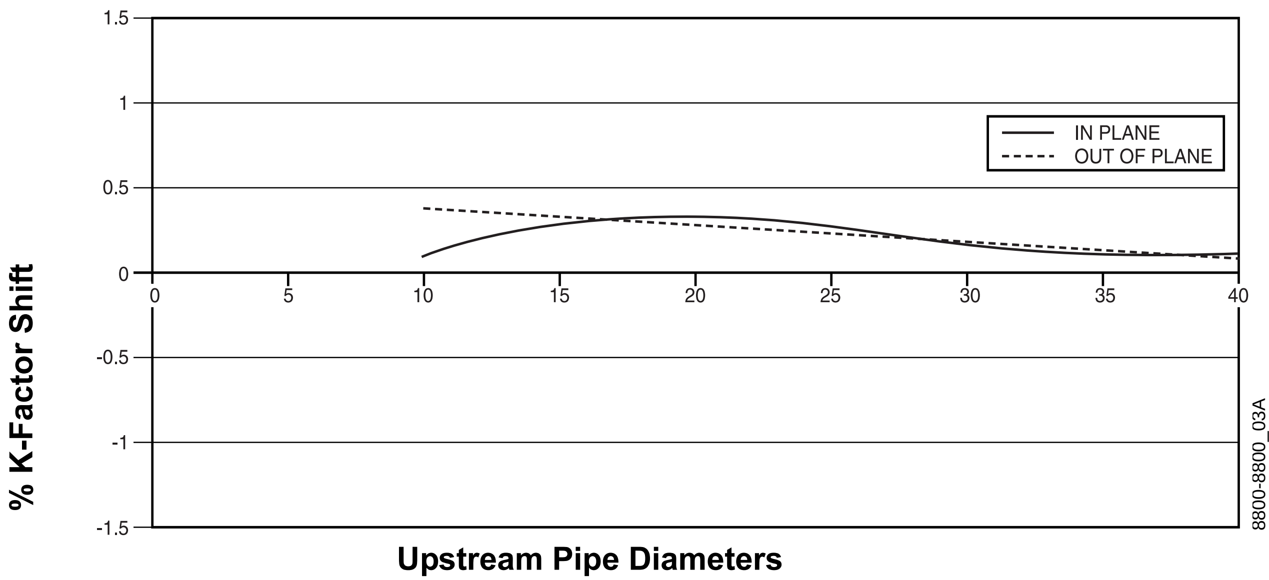


FIGURE 7. Reducer

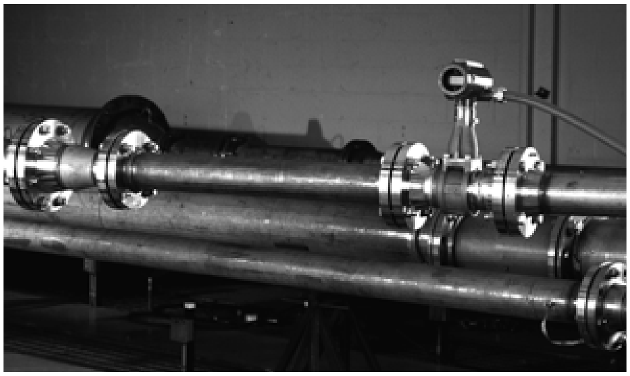


FIGURE 8. Reducer Graph

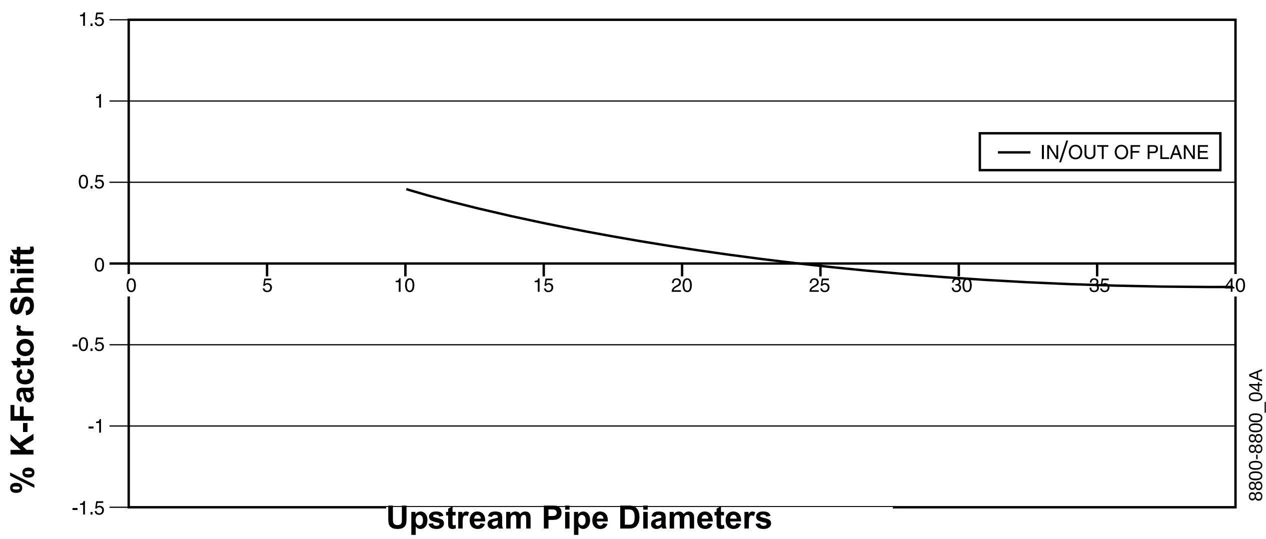
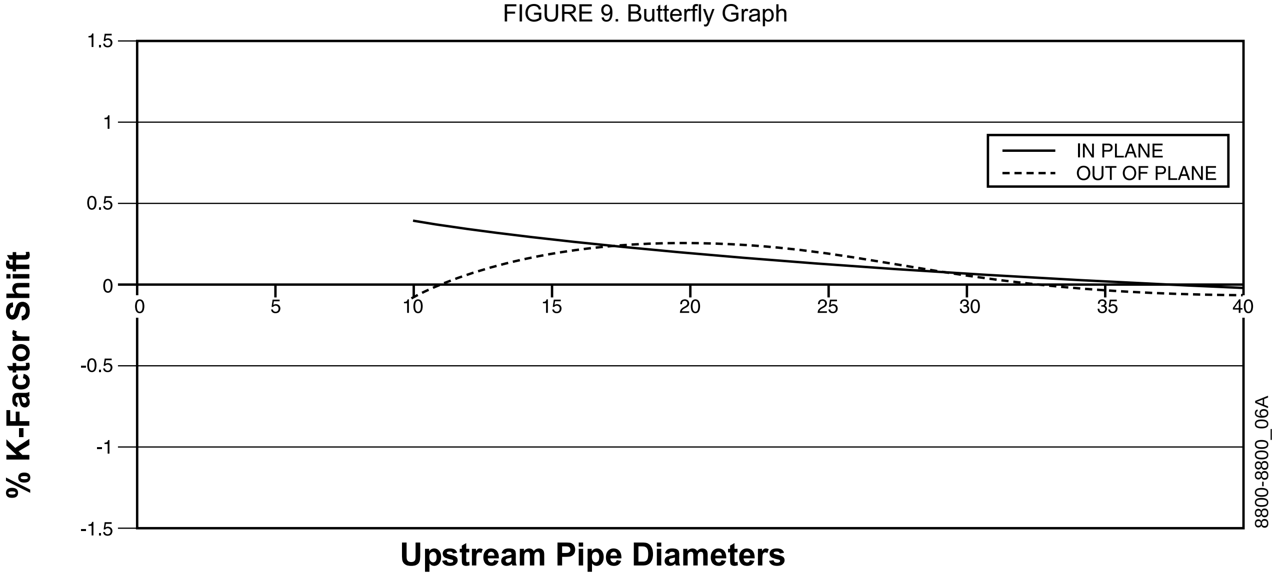


FIGURE 9. Butterfly Graph



Rosemount 8800

Emerson Process Management

Rosemount Division
8200 Market Boulevard
Chanhassen, MN 55317 USA
T 1-800-999-9307
T (International) (952) 906-8888
F (952) 949-7001

www.rosemount.com

Emerson Process Management
Heath Place
Bognor Regis
West Sussex PO22 9SH
England
T 44 (0) 1243 863121
F 44 (0) 1243 867554

Emerson Process Management Asia Pacific Private Limited
1 Pandan Crescent
Singapore 128461
T (65) 6777 8211
F (65) 6777 0947
Enquiries@AP.EmersonProcess.com

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