
Technical Article

The Challenge of Flow Disturbances on Meter Accuracy

By McCrometer

Accurately measuring flow is critical for water utility operations. Also, regulatory agencies mandate flow monitoring and require annual calibration of meters. But even a meter in perfect condition and properly calibrated can read inaccurately. Flow disturbances are a common cause of accuracy and repeatability errors.

What Causes Flow Disturbances?

Flow meter manufacturers recommend providing a minimum distance of straight pipe upstream and downstream of the meter. Improper flow meter installation or pipe configuration can create flow disturbances that affect the velocity profile. The result is erroneous flow measurement.

Flow disturbers include tees, elbows, and reducers. Partial obstructions such as partially closed valves, butterfly and check valves, control valves, screens, and probes create disturbances. Even a poorly installed flange gasket may create problems.

The two most common types of flow disturbance are asymmetric velocity profiles and swirl. Asymmetric flow occurs as water flows around an elbow. Imagine the flow coming through an 8-inch pipe main going through an elbow at three feet per second. As the flow presses against the outside pipe, it makes a violent turn, then overcorrects. Eventually, it changes to a turbulent flow. Anyone who's enjoyed being sloshed around on a water slide can get the general idea.

Similarly, think about water flowing from a 4-inch pipe then changing to a 10-inch pipe. If the flow is low, there may be little impact. But if the flow velocity is fast, the effect will be like a nozzle, with a jetting effect.

Two elbows out of plane can create a swirl — an asymmetric profile with a single vortex. Swirl can take numerous pipe lengths to fall off and return to a normal profile. It can create significant measurement errors.

A control valve can cause both asymmetric flow and swirl, depending on velocity and how open the valve is.

Flow Disturbance Effects

Flow disturbances may cause flow meters to under-read or over-read. The degree and direction vary widely, depending on the metering technology and other factors. For instance, flow velocity can greatly change the effect. The faster the water is flowing in the presence of a disturber, the more violent the reaction to the obstruction or bend.

The amount of error can be great. For example, flow disturbance caused by a butterfly valve can result in erroneous readings of over 50 percent for certain meters.

The effects of flow disturbances cannot be generalized. There are many types of meters to serve various applications. Flow disturbances affect each type of meter differently. For instance, flow disturbances would typically cause an electromagnetic (mag) meter to under-report flows. For a propeller meter, the direction of swirl could create either under- or over-reporting.

Addressing Flow Disturbance Effects

Some flow disturbance errors are caught after a system is already in service. Other problems arise

during projects to upgrade or modify a system. A flow meter may need to be added, changed, or relocated. Appropriate lengths of straight pipe may not be available.

Planning and Design

For new or modified systems, the best way to prevent flow disturbances begins during the planning process. Sometimes, the meter location is determined after a complicated piping design is finished. During system design, the engineer should work closely with a flow meter manufacturer to determine the best meter for the application. Then, follow the manufacturer's guidelines for the length of straight run pipe during system design.

System Modification

If flow disturbances are creating errors, the problem may be resolved by correcting or modifying the system. Ensure valves are fully opened, relocate valves, modify the piping system, or relocate the meter. However, this may be a difficult and costly solution.

Replace the Meter

In some cases, replacing the existing meter with a different type of flow meter can solve the problem. As noted, flow disturbance varies depending on meter type. In other cases, it may be possible to adjust for the disturbances electronically.

Flow Straighteners and Conditioners

Sometimes, space constraints or other issues don't allow enough straight pipe to prevent disturbances. Flow straighteners and conditioners can reduce the amount of straight pipe needed.

Flow straighteners can remove swirl and are typically tube shaped. Flow conditioners are wafer-shaped devices with holes that remove both swirl and asymmetric flow. Be aware, they do not work with every type of meter. For instance, a flow straightener worsens the disturbance on a mag meter.

Take Advantage of Available Expertise

Erroneous flow readings can result in process problems, regulatory violations, and wasted dollars.

Flow meter manufacturers have a depth of experience and are willing assist with flow meter selection and system design. They can often help with computer aided design (CAD) of fluid dynamics. Engaging the assistance of a technical partner ensures the selected meter will provide accurate and precise flow measurement.