Proving Coriolis Flowmeters

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Introduction

Coriolis meters measure mass flow rate and density. The measurement of the Coriolis force exerted by the flowing fluid on a vibrating tube provides a measure of the mass flow rate. At the same time, the frequency of the tube's vibration is related to the density of the flowing fluid. The meter is capable of indicating volume rate by dividing the measured mass rate by the measured fluid density.

Coriolis meters have no mechanical moving parts to wear. Therefore, theoretically the performance of a Coriolis meter should not change with time. If this is true, why should you prove a Coriolis meter? When or how often should you prove a Coriolis meter? And how do you prove a Coriolis meter?

Why should you prove a Coriolis meter?

There is no such thing as the perfect meter. Because of manufacturing limitations, all meters have a margin of error. This margin of error can be numerically or mechanically corrected in the field by meter proving. The numerical correction for a meter's margin of error is referred to as a Meter Factor and is determined by comparing a prover's known volume with the meter's indicated volume.

Meter Factor (MF) = Prover's Known Volume ÷ Meter Volume

A meter's margin of error (referred to a meter factor or MF from here forward) can be influenced by installation and fluid conditions. The effects of installation and fluid conditions on a meter's MF are dependent upon the meter's design.

When or how often should you prove a Coriolis meter?

A Coriolis meter should be proved when it is first put into service and on a regularly scheduled basis thereafter. The meter needs to be proved any time the meter is subjected to changes in conditions, which might cause a change in measurement accuracy. API Manual Chapter 5.6 recommends a meter proving if any of the following events occur:

1. Anytime the meter is rezeroed.
2. When the flow sensor installation or mounting conditions are modified.
3. When the Coriolis meter density measurement is calibrated, if the meter is configured to indicate volume.
4. When the meter assembly is repaired.
5. When any of the assembly components have been replaced.
6. If a change in the fluid temperature, pressure, or density occurs beyond user-defined limits as determined from field experience.
7. When a flow rate change occurs that will cause a shift in the meter factor in excess of predetermined tolerance limits. The meter factor shift due to flow rate shall be determined from field proving experience.
8. Anytime the accuracy of a meter is in question.
9. When a change in the direction of flow through the meter occurs, if a meter factor has not been determined for the new direction.

The main objective of a meter proving is to obtain the most accurate product accounting possible. Therefore more provings might be required for a new installation, and as confidence in the meter becomes established, the level of provings can be decreased.

How do you prove a Coriolis meter?
The methods used to prove a Coriolis meter are direct mass, inferred mass, and volumetric. How a Coriolis meter is proven depends on how the fluid is being transferred. In other words, is the fluid being transferred in mass units or in volumetric units?

If the Coriolis meter is being used to measure mass, a direct mass or inferred mass method may be used to prove the meter. In a direct mass proving (refer to figure 1), the mass of the fluid in the prover is physically measured and is then compared to the meter's mass to determine a meter factor. In an inferred mass proving, the mass of the fluid in the prover is calculated by multiplying the volume of the prover by the density of the fluid in the prover.

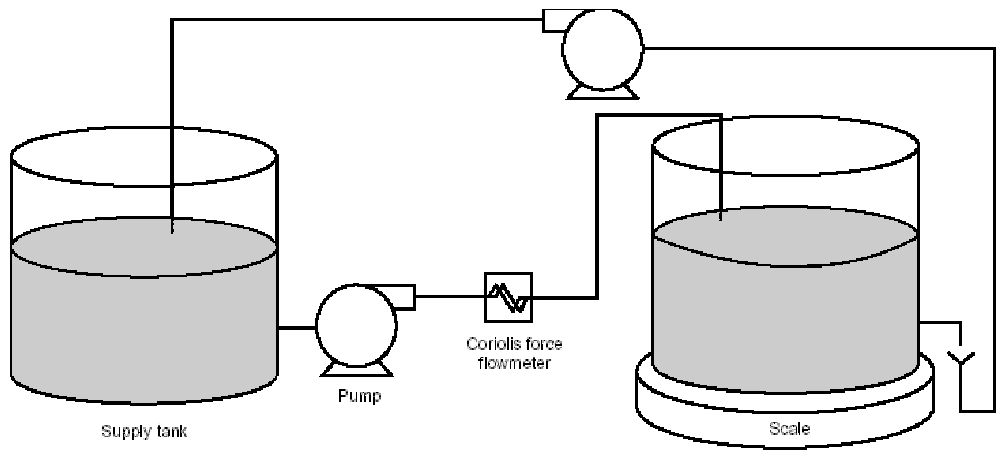

Figure 1

When a Coriolis meter is configured for volume measurement, the meter's indicated volume can be compared directly to the prover volume. The meter's volumetric flow rate is calculated by dividing the measured mass rate by the measured density.

$$Q = \frac{M}{\rho}$$

Where:

Q = Calculated volume flow
M = Measured mass flow
ρ = Measured density

The equipment needed to prove a Coriolis meter by volumetric method includes (refer to figure 2):

- Prover with a calibrated volume.
- Thermometers of the appropriate range (accurate to one-half degree Fahrenheit).
- Pressure gauges (calibrated to an accuracy of two percent of full-scale reading).
- Valves to divert flow (Any valve in the meter proving system or loop that could allow liquid to by-pass into or around the meter or prover must be of the type that will allow it to be checked for leakage when it is in the closed position).

- Prover counter or pulse counter (used to count the flow pulses from the Coriolis meter).
- Hydrometer (used to get an observed gravity of the liquid flowing through the Coriolis meter).

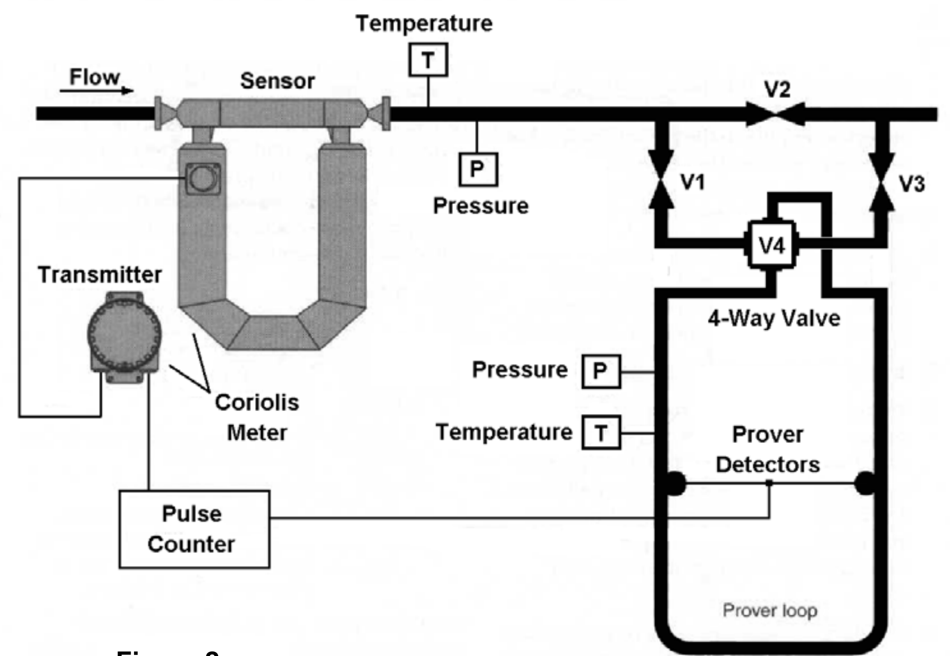

Figure 2

Conclusion

A meter factor is a dimensionless number calculated to correct for a meter's margin of error. The meter factor is calculated by comparing the meter's indicated measurement with a prover's actual measurement of the fluid. A meter's meter factor can be influenced by installation and fluid conditions. Therefore, the meter should be proved at conditions as close to the normal operating conditions as possible. Fluid conditions should also be as stable as possible.

A Coriolis meter is capable of measuring mass and density directly and, therefore, indicating volume. The prover's quantity should match the engineering units of the meter's output.

Prove the meter as often as necessary to develop confidence in the meter's performance.