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General Information on Flowmeters

Where does meter accuracy variation come from …

Machining tolerances:

Variation within a production run is normally minimal. The run is sized so as to not allow tool wear to shift the tolerances. In the case of the typical cold-water meter, the inside of the working chamber is machined in two passes. A variation of about 0.0002" (two ten-thousandths of an inch) on the depth of the cut across the bottom, will shift the accuracy about 0.1%. In general, the lower the viscosity of the fluid, the greater the accuracy loss with this type of machining variation.

You can see machining error in the working chamber, it will appear as a slight line in the center of the space between the hub and the inside wall. You will probably never see this in a typical water meter.

Temperature variations:

Meter tolerances are designed for "ambient" operation. On typical oil meters, with temperature rises the anodized aluminum piston and the brass working chamber will expand at different rates, varying the gap between the piston OD (outside diameter) and the chamber ID (inside diameter). This will change the amount of leakage through the meter.

Testing technique:

Testing technique, especially on oil meters is important. The test container should drain fully, or at least be positioned in an immovable position so as to get repeatability of any trapped fluid after each drain down period. One should always fill the test container and drain it for a preset period of time. This will provide a uniform oil film on the inside tank walls (technical term is "clingage"). With a nonuniform film from run to run, the operator will observe apparent meter non-repeatability and accuracy error. On heavier oils film thickness variation can severely distort test results.

Flow rate adjustment during the test cycle… the operator will tend to slow down the flow rate at the end of the test in order to meter out a known volume precisely. They will frequently drop the flow below the minimum flow rate of the meter, and introduce a serious error for that period.

Gravimetric testing:

Testing by weight is one of the best ways to evaluate a meter's accuracy. However, if a movable platform scale, either mechanical or electronic, is used … has it been banged around, is it still accurate?

Typically, a customer will place a 55-gallon drum on a weigh scale, take a tare weight, fill the tank and convert the weight to gallons to check the meter. Assume that he runs 50 gallons (417.26 pounds) of water. To this 417.26 pounds you add the tare weight of the drum and arrive at something on the order of 450-460 pounds. An error of 1/2% percent on the meter is 1/4 gallon or 2.08 pounds. The question is whether the customer can read a tare weight at 30-40 pounds and a total weight of 450-460 pounds, subtract the two readings and have enough accuracy in his two measurements to properly judge the flow meters performance.

This reading resolution and accuracy is possible with an electronic scale with load cells, but can be very questionable on a mechanical scale. People kid themselves about the accuracy of their scales.

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Plastic bodied meters:

If the customer uses a clamping device which exerts a compressive force on the meter ends, it is possible to distort the body shape, and create a gap between the fit of the working chamber and the body. This allows leakage around the working chamber, and creates a "low" reading on the register.

The best way: The best measuring system uses an electronic gravimetric (weighscale) scale with a flow diverter. You run the water through the flow meter at a preset rate and as the pointer crosses a cardinal point you hit a button. This button actuates a cylinder which diverts the flow into the weigh tank. When the pointer passes another cardinal point, you hit another button and the diverter flips back to the original position. The result is a uniform rate of flow test with high accuracy. In a production situation, one would normally use a photosensor which detects the pointer position, thus eliminating human variation and reaction time.

General ... Comparison test meter

Turbine meters such as the Turbines, Inc. turbine flow meters are typically used as comparison test meters. They come with 10-point calibrations with NIST traceability, are 1/2% (or better), they are small, portable and easily stored. However, you have to treat them properly:

A comparison standard meter which is removed from the flow line and only used for periodic testing requires flushing after each use. To eliminate the small deposits which form when water is evaporated, the meter should be flushed with alcohol and allowed to air dry before storage. We recommend the use of 95% denatured ethyl alcohol which is commercially sold as "stove alcohol". As a alternative, 91% isopropyl alcohol containing less than 0.003% by weight non-volatile material can be used. Do not use wood alcohol (methanol), rubbing alcohol, or ethyl alcohol with non-volatile denaturing additives. The flow meter is a precision turbine and while it can tolerate some abuse, to avoid a shift in accuracy or response due to buildup of foreign matter in the bearing structure, proper care prior to storage is recommended.

To obtain the full accuracy potential of the turbine meter, it must be installed in a laminar flow situation in horizontal piping. This means at least 10 horizontal pipe diameters of straight pipe ahead and 5 horizontal diameters after the meter.

General ... Installation notes and commentary

If the flowmeter is a turbine design, vortex shedding, paddlewheel:

Allow as much straight pipe, in the same size as the flowmeter line size, before and after the meter. The minimum should be 10 pipe diameters ahead and 5 pipe diameters after the meter. If you have a 4" meter, this means 40" ahead of the meter and 20" after the meter.

If the flowmeter is a positive displacement design, straight pipe is not an important issue.

Some general comments:

Flowmeters do not work well with silty or dirty fluids. Use strainers ahead of the meter if this is your situation.

Teflon™ tape, pipe dope ... do not, under any circumstances, get tape or pipe dope over the end of the connecting pipe. When screwed in, it will break free and wash into the flowmeter. This means trouble. Does the meter match the application?

... if you have hot water, is the meter rated for it?
... if you have chemicals, can the meter handle the fluid?
... is the line full? The meter must not have any air in it.

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... if a gravity line installation, is there enough head pressure?
... think about your installation, what can create a problem?

After installation, don't open a valve and have water come rushing down the pipe at a high rate. The escaping air will cause the meter element to spin rapidly and in extreme cases self-destruct. When the water reaches the meter a high velocity wall of water can damage the meter when it hits the working element.

Water hammer. This is what you hear in a pipe which has a high flow rate going through it and you slam a valve closed quickly. Moving water has a lot of energy in it. If you have a 2" pipe system with about 100 gallons of water distributed through it, and it is flowing at 200 GPM, this moving water looks like 830 pounds moving at 13 MPH. When that valve slams closed, you are asking it to stop that 830 pounds instantaneously. The bang you hear is a shock wave. This shock wave can make pipes split open. Avoid water hammer by using slow closing valves, or valves which close in 2-stages, reducing the water flow before doing the final closing.