Low Cost Solution Increases Orifice Meter Rangeability From 2/1 to 8/1

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Abstract

To meet today's challenges of reducing orifice meter plate change costs, TransCanada has developed a retrofit solution that utilizes existing digital transmitters and differential pressure double/triple stack flow computers to increase rangeability from 2/1 to 8/1. This increase in operating capability is achieved through the addition of an industry standard interface module that can be installed directly at the flow computer with minimal wiring changes.

What Is Rangeability and Why Is It Important?

Metering rangeability is the ratio of the maximum to minimum flow the meter can measure. For example if a meter can measure from 150 e3m3/day to 300 e3m3/day, then the rangeability is 300/150 which is 2/1 when reduced to its lowest common denominator. The volume a meter can measure changes as operating pressure and temperature change. Although the theoretically rangeability can increase, in practice the rangeability usually decreases.

To calculate the minimum expected rangeability the operating pressure and temperature range must be determined. Use the minimum pressure, maximum temperature and maximum meter output to calculate the lowest maximum flow rate. The opposite combination of maximum pressure, minimum temperature and minimum meter output is used to calculate the highest minimum flow rate. If composition varies significantly it needs to be factored into reducing the maximum flow rate and increasing the minimum flow rate.

Rangeability for ultrasonic, turbine and RD meters is extremely important because the metering capability cannot be changed with changing the meter. Under-sizing of the meter results in accuracy problems in ultrasonic meters and accuracy/damage of turbine and PD meters. To avoid this problem the meters are usually sized with a maximum metering capability less than the maximum output. If a meter is sized for a maximum of 70% of meter capacity to allow for operating fluctuations and future growth, then the stated rangeability of the meter is also reduced. A meter with at 50/1 rangeability if it was operated to its maximum flow is reduced to 35/1 rangeability when sized for a maximum flow rate of 70%.

Rangeability for orifice meters typically limited to ~2/1 for a single plate size and single differential pressure transmitter. The good news with this type of meter is the metering capability can be changed by simply changing the orifice plate and/or the differential pressure transmitter range. The result is a meter with a rangeability of ~70/1 to >100/1 with a simple plate changes and re-spanning of the differential pressure transmitter. For production the 2/1 rangeability of the single plate/transmitter is able to meet normal operating changes. If the operating conditions change, for example due to nomination changes, a simple plate change is all that is required to meter to these new conditions. If the plate change is not coordinated with the change in operation then the meter will measure inaccurately until the plate is changed and there is usually no damage to the meter unless the meter is over-ranged substantially. Usually the damage is limited to a bent orifice plate that is economically replaced. The bad news is changing the orifice plate costs $$$.

What Limits Orifice Meter Rangeability?

Orifice meter rangeability is limited by the differential pressure transmitter analog input to the flow computer. The first limitation is the analog accuracy of the differential pressure transmitter. Transmitter accuracy is stated as a % of span and generally exceed acceptable % of reading accuracy limits at ~20% of span (See Figure 1 below).

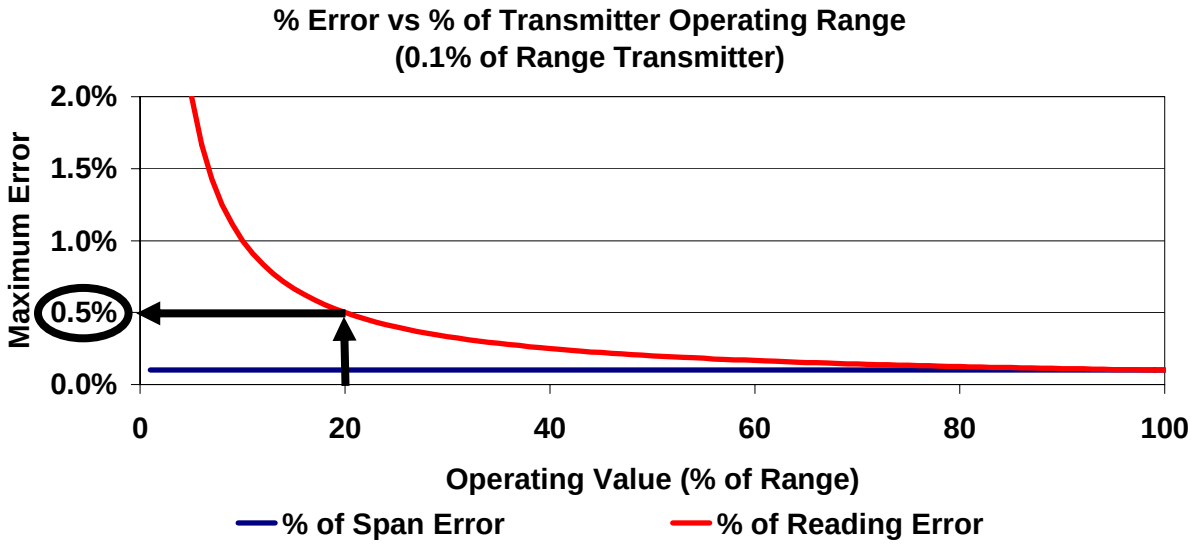


Figure 1

The second limitation is the flow computer A/D (analog to digital) conversion process. The A/D has accuracy, repeatability, linearity and monotonocity accuracy limitations. For example a 12 bit A/D has:

- a maximum resolution of 4096 counts
- the transmitter 4-20 ma output further reduces this resolution to approximately 3275 counts
- at 20% of the transmitter range the A/D conversion is approximately 655 counts
- a 1 count A/D error due to linearity, hystoresis, repeatability or monotonocity is 1/655 which is approximately 0.15% of reading error

The additive nature of transmitter errors and flow computer errors can be minimized by calibration of the transmitter to the flow computer

So that's not bad is it? At 20% of range:

- The rangeability is 100% / 20% = 5 to 1
- The accuracy is ~ 0.5% to 0.7% of reading (0.5% for the transmitter and 0.15% for the A/D)

But wait, isn't flow proportional to the square root of differential pressure. That would make the volume error ½ of the differential pressure error making the volume error ~ 0.25% to 0.35%. Adding in the static pressure and temperature transmitters errors makes the volume error due to instrumentation ~ 0.3% to 0.5%. Before you start cheering too loudly you also need to remember that makes 20% of differential pressure range ~ 45% of maximum flow and reduces the rangeability only ~ 2 /1.

So How Do We Increase The Rangeability With-Out Reducing Measurement Accuracy or Doing Plate Changes?

The most common method to increase rangeability is to use two or three differential pressure transmitters, calibrated to different ranges and set the flow computer up to switch between transmitter inputs as the differential pressure changes. (See Figure 2)

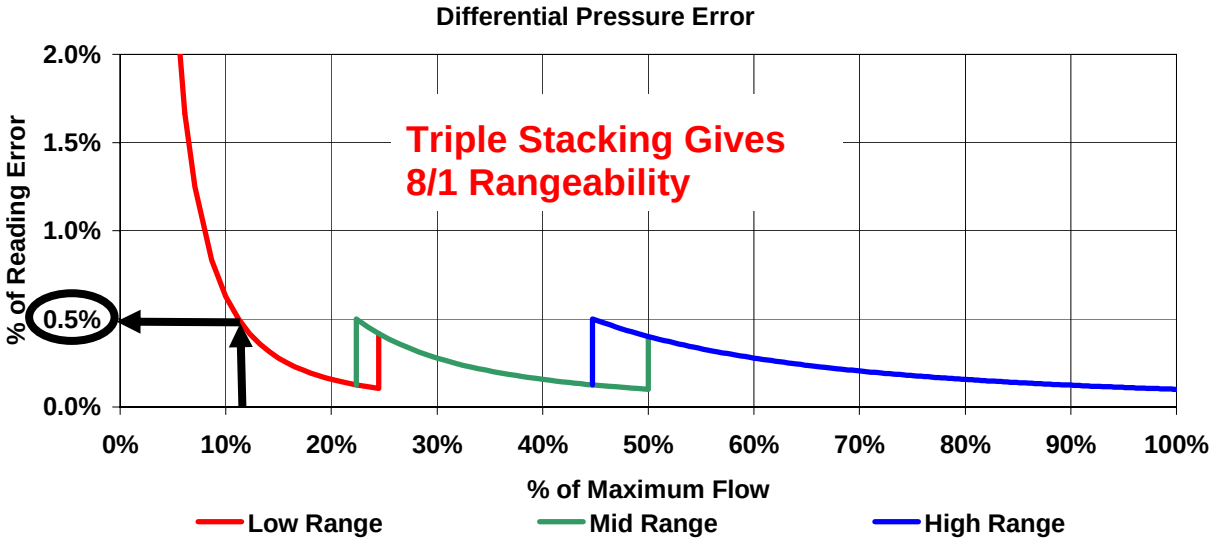


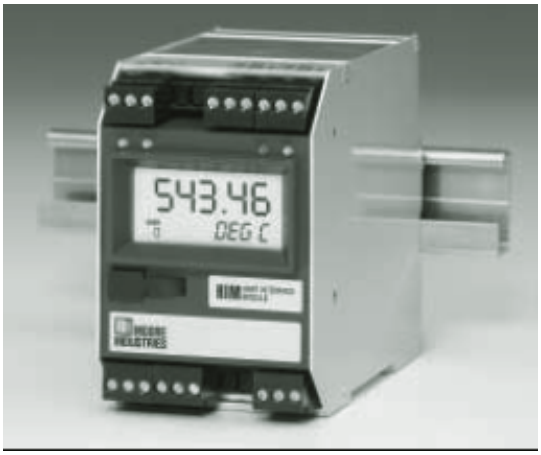
Figure 2

So how does this work in real life? You start with a single with a typical pressure/differential pressure transmitter installation.

Then you add two more differential pressure transmitters, valves, tubing and wiring:

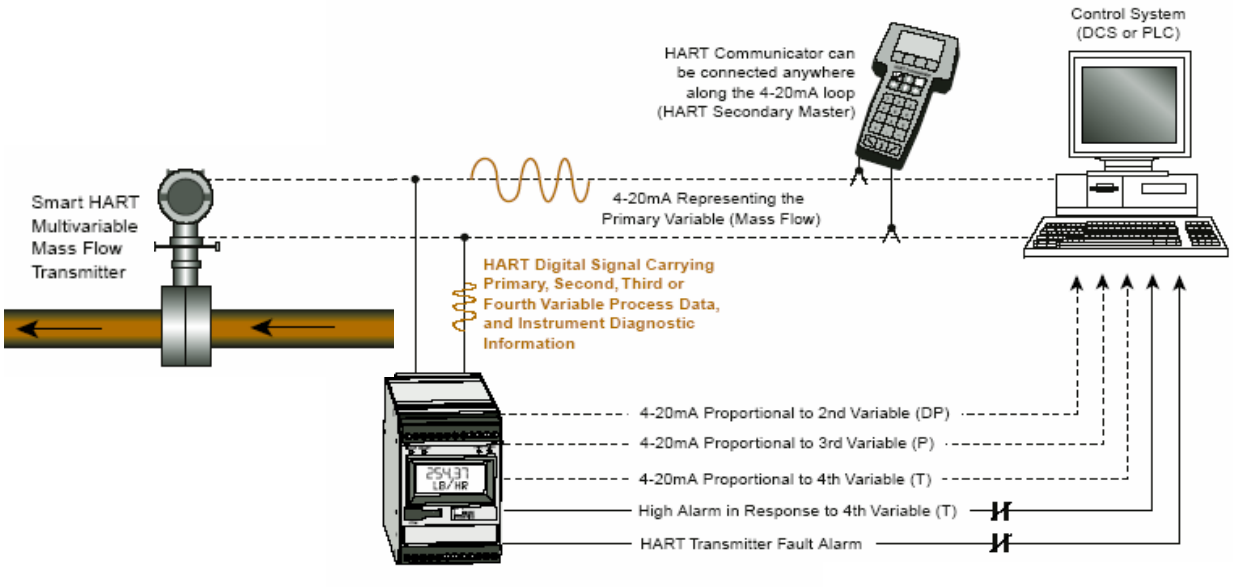
and don't forget the wiring back to the instrument building and possible trenching. Can you count the dollars? But wait, weren't those "smart" transmitters and why would that matter?

"Smart" transmitters in analog mode have improved performance due to pressure and temperature compensation but are still limited to 20% of range as the lower practical operating limit due to transmitter D/A and flow computer A/D conversion electronics. In digital mode they expose the transmitter cell inherent accuracy by eliminating the D/A and A/D conversions and the majority of the % of span limitations if you flow computer supports their digital input. To use the transmitter digital capability with existing flow computers that only support analog inputs requires the addition of an interface module that will take the digital input from the transmitter and convert it into multiple analog outputs.



HIM ("Hart" Interface Module)

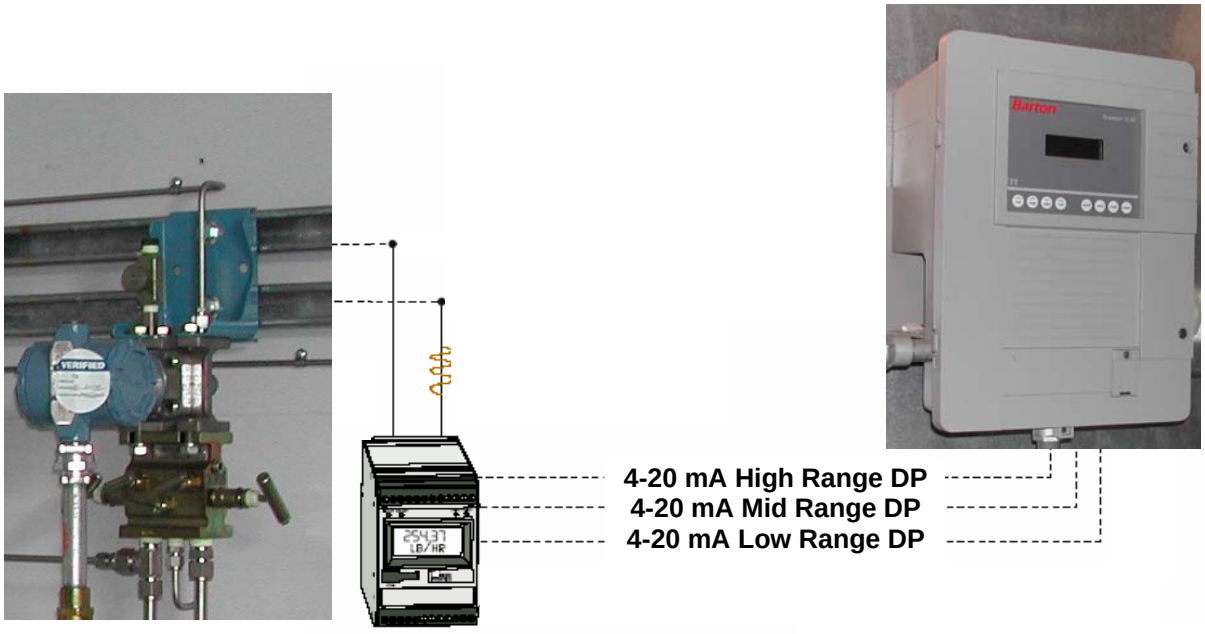
But wait, doesn't the module say Deg C and doesn't the brochure say:



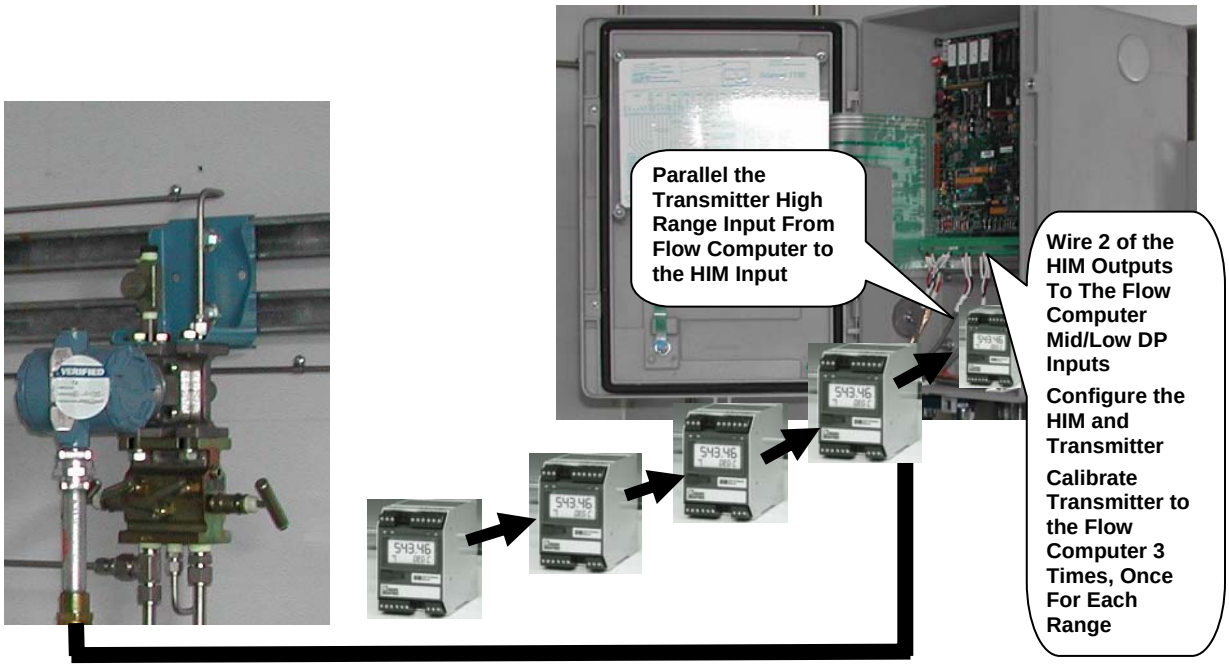
A couple of calls to the vendor asking

- Why can't the input be a single smart differential pressure transmitter and the outputs be three different analog differential pressure ranges?

and the answer was yes.



While you are at it, just install the “HIM” in the flow computer with a few limited wiring and configuration changes. The result is a simple cost effective upgrade that increases metering rangeability from 2/1 to 8/1.



Conclusion

By adding one “HIM” and a little flow computer wiring and configuration it is possible to extend the measurement rangeability of an orifice run with a “smart” differential pressure transmitter from 2/1 to 8/1. This increased rangeability reduces the need for plate changes without the need for the costly addition of transmitters, valves, tubing, gas service building wiring or trenching.