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Considerations For Using Large Diameter Coriolis Mass Flow Meters In Oil & Gas Applications

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During the last decade manufacturers have been launching larger Coriolis mass flowmeters to satisfy the requirement for mass flow measurement in larger line sizes for bulk fluid transfer applications in oil and gas, chemical or petrochemical industry segments. The high performance mass flow and density accuracy specifications of the Coriolis flowmeters have made this technology become more and more popular. Until now, there were very few manufacturers producing larger line size Coriolis flowmeters in the market.

The designs of these meters are very different as compared to smaller diameter offerings and also from each other. In **Figure 1** you can see two popular types of designs that were available as of 2016. Both designs are quite substantial in order to accommodate the bigger flow tube diameters needed to achieve the needed flow rates. One meter features a prominent U-shaped bend while the other is more round in appearance. The U-shaped meter features two separate tubes with a flow splitter at both end connections. The round meter features two pairs of two tubes and the associated flow splitters, with each pair of tubes on opposite sides of the end connections. As the diameter increases, the footprint size becomes larger and the weight gets substantially heavier. This creates installation and design challenges for the user companies, engineering firms or for measurement skid integrators and fabricators .

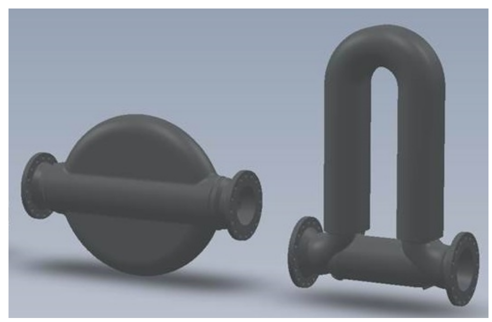

Figure 1: Sensor housing designs of large size Coriolis flowmeters as of 2016

Installation Considerations

There are two basic options for installing these types of meters; either horizontally, with the bends parallel or perpendicular to the ground, or vertically in the ”flag position”, with the bends flaring out from the pipe.

Of the two designs shown in Figure 1, let’s consider the U-shaped meter in a horizontal installation on liquids. In this condition, to keep the meter full of liquid and avoid gas pockets, you would install the meter with the tube’s bend perpendicular to the ground and below the flow pipe. Often there is a challenge for a U-shape design since pipelines are mostly only a few feet above the ground. There is no space to put the meter’s “belly” in this situation unless expensive civil engineering and constructions is expended to dig a sump to accommodate the meter. Keeping the sump clean of debris, water or ice and snow would then be an extra consideration since you would not want to have the meter submerged in any way.

Where two parallel pipelines are close to each other it's also difficult to install either the round design or U-shaped meters in a horizontal position since there is not enough space for the bellies between two parallel pipes. A pipe outbreak would be required to install these meters in a horizontal position. For the U-shaped design, the flag position will increase the footprint of the measurement skid significantly and makes construction and installation of the measurement skid more expensive and difficult. Additionally, added mass in the meter itself may cause mechanical stresses on the measurement tubes when mounted vertically resulting in noise and potentially inaccurate measurement.

Custody Transfer

Flowmeters in custody transfer applications have to be proven in the field frequently. The proving is mostly done through Small Volume Provers (SVP). An SVP pushes a known "small" volume through the meter and the pulses of the flowmeter are counted. Every missed pulse can influence the uncertainty and repeatibility negatively. For good proving results, a very consistent zero stability is key. Zero stability is an indication of the consistent performance of a filled flowmeter in zero flow conditions. Noise and mechanical tension on the measuring tubes influences the zero stability which can lead to poor proving results.

What the market needs

Upon evaluation of the most common needs, the most common request is for a small installation envelope and mounting flexibility. Being able to install meters in close proximity to other pipes or without having to adapt other equipment, such as catwalks or platforms would help optimize a package design and reduce costs associated with transport.

The design should also easily adapt to any mounting requirements, whether vertically or horizontally or anywhere in between, with no influence on the accuracy and zero stability of the meter and without mechanical stress on the measurement components.

Other needs include suitability for the environment such as hazardous area approvals; traceable calibrations; secondary containment; custody transfer performance with field proving using small volume provers, and a wide variety of communications options and diagnostics tools.

KROHNE's solution

KROHNE recently launched their newest addition to the OPTIMASS family. It is a large diameter Coriolis mass flowmeter that features four straight tubes with the smallest installation envelope of its class. With a maximum measurement range of 695,000 Barrels per day, it features the highest flow capacity of any Coriolis meter on the market.

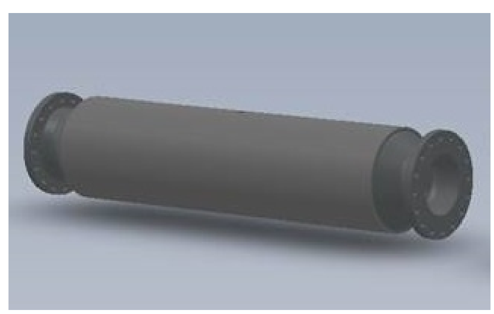

Figure 2: Design of Large Straight Tube Sensor Housing Coriolis Flowmeter

As shown in **Figures 2 and 6**, its unique cylindrical straight tube configuration allows it to be installed like any other piece of pipework due to the rigid secondary containment housing design which can handle pressures up to 2175 psig. Also, upstream and downstream runs are not required since Coriolis meters are independent of the Reynolds number and flow profile effects. Accurate and reliable measurement is possible in very compact measurement skids and this alone can result in very, very significant savings in construction, installation and transportation costs to the end customer.

Pumping liquids through a large line size bent tube Coriolis mass flowmeter in the flag position causes a large pressure drop which results in high pumping costs over the year. KROHNE's four straight tube Coriolis mass flowmeter with the optimized flow splitter design **(Figure 3)** reduces these pumping costs and also benefits the user with significant savings.

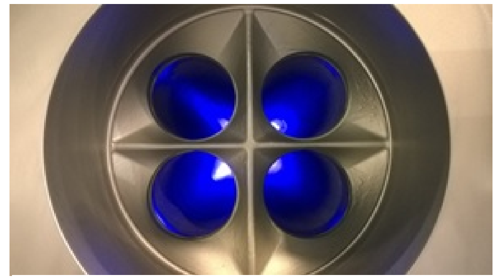

Figure 3: Four way flow splitter design

Installation immunity

As previously mentioned, to measure bulk flowrates accurately a Coriolis mass flowmeter requires a very good zero stability. KROHNE mechanically isolates the measuring tubes of the meter from the process using their patented node plate technology. The node plates dampen any kind of vibration and noise in the process. Stresses caused by torque from piping offsets are redirected over the outer casing of the meter, which is constructed of schedule 160 pipe, to prevent the meter accuracy from being affected.

The node plate technology shown in **Figure 4** was first used in dual tube flowmeters and was migrated

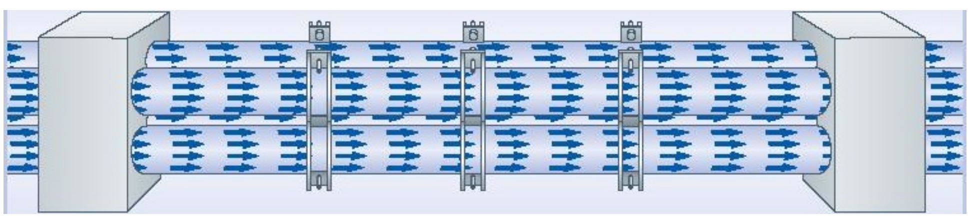

Figure 4: Unique patented node plate technology

into the new four straight tube Coriolis mass flowmeter. The isolation is so effective that if necessary the meter can be clamped directly at the meter body to support the weight of the meter.

Traceable Calibration

It takes a very big calibration rig to calibrate the largest available Coriolis Mass flowmeters. At the KROHNE production facility in Wellingborough in the UK, where KROHNE's center of excellence for Coriolis Mass flowmeters is located, they developed the largest mass flow calibration rig in the world to take on this challenge.

To calibrate a flowmeter to ±0.05% accredited measurement uncertainty, the calibration rig has to be at least three times more accurate. The new large mass flow calibration rigs are accredited by UKAS, England's metrology agency, to an uncertainty of less than 0.017%. The new calibration rigs allow for calibration of the OPTIMASS 2400 S400 16" Coriolis Mass flowmeter with flows to 60% of the nominal meter capacity. As shown in **Figure 5**, this flow rig is the single largest one of its type in the world.

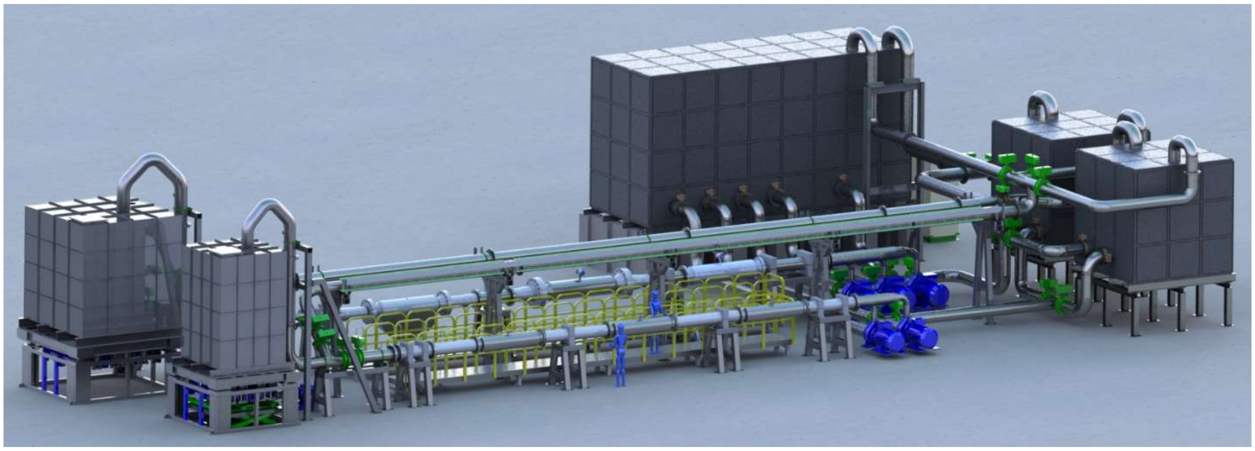

Figure 5: The new KROHNE "mega rig" for mass meter diameters to 12 inch (front) and "giga rig" for up 16 inch (back)

Highlights of the OPTIMASS 2400 S400:

- Innovative four measuring tubes design with a large tube size, high flow capacity
- High accuracy for custody transfer
- Easy to drain and easy to clean
- Optimized flow splitter for minimum pressure loss
- Patented node plate technology for measurement isolation
- Super Duplex option for operating pressures up to 180 barg; 2,610 psig
- Secondary containment up to 150 barg; 2,175 psig

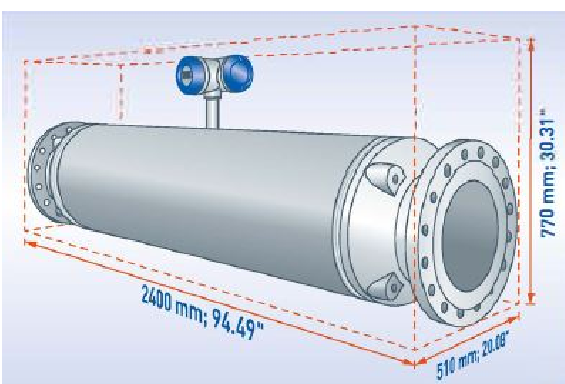

Figure 6: Compact installation envelope

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