

Cryogenic Service with Micro Motion® Flowmeters

Abstract

Accurate measurement of cryogenics poses special problems for traditional technologies which are solved with Coriolis technology. Micro Motion can provide site-specific recommendations for the greatest possible flow performance for your cryogen of interest. Micro Motion® Coriolis meters deliver accurate and reliable flow measurement when the appropriate sensor is selected.

Introduction

Industrial gases are often moved or stored in a cryogenic liquid state, that is, at cold temperatures and pressures slightly above vapor pressure. At cryogenic conditions, these liquids provide little lubrication for moving parts, thereby creating major challenges for traditional turbine and PD (positive displacement) flowmeters. In addition, the thermal shock of fluids at these low temperatures presents material compatibility concerns when using O-rings, glands, or dissimilar metals as wetted parts. As a result, reliable measurement of cryogenic liquids is difficult with traditional technologies.

Micro Motion Coriolis sensors are well-suited for cryogenic service because a sensor with no moving parts and no wetted dynamic components is immune to many of the mechanical issues related to cryogenic measurement.

Additionally, Micro Motion has developed a set of best practices that can help you ensure that the Micro Motion flowmeter will be successful in a cryogenic application. This white paper documents these best practices, and also provides answers to several frequently asked questions.

Best Practices

1. *Use Micro Motion ELITE® sensors with MVD™ DSP technology*

The pressure drop and turndown specifications of the Micro Motion ELITE® sensor, combined with MVD™ DSP (multi-variable digital signal processing) technology in the electronics, make it the instrument of choice for cryogenic applications. Since 2001, MVD technology has included an algorithm that automatically corrects the stiffness of the flow tubes at cryogenic temperatures. When this is implemented with ELITE sensors, accuracy is maintained at the low end of the flow range. This correction is not included in older, non-DSP electronics.

Note that the liquid accuracy specification for ELITE sensors does not apply at cryogenic temperatures due to increased variability of the tube stiffness at these extreme conditions. At cryogenic temperatures there is an immunity to entrained bubbles. Expect performance to fall within the gas accuracy specification: typically $\pm 0.35\%$ of rate when used with MVD technology.

2. *Carefully size the sensor to reduce the likelihood of flashing and to optimize measurement performance*

The only significant production cost in making cryogenic liquids is the cost of the energy required to cool gas to cryogenic temperatures. Any cooling below the vapor pressure is viewed as an unnecessary expense. Therefore, as a cost-containment measure, cryogenic liquids are usually transferred at pressure very close to their vapor pressure. This means that any large pressure drop in the system could induce the fluid to flash into a two-phase state, making accurate flow measurement unnecessarily difficult. The best practice when sizing and selecting a Coriolis meter for a cryogenic application is to keep the pressure drop low.



To calculate the maximum allowable pressure drop and avoid flashing, refer to Figure 1 and use the following equation:

$$P_{out} \geq (3 \times P_{dP}) + P_{vp}$$

Micro Motion Product Advisor has codified these safety factors. Please see www.micromotion.com for more information.

where:

- P_{in} = Inlet pressure
- P_{out} = Outlet pressure
- P_{dP} = Pressure drop across sensor (from Micro Motion sizing program)
- P_{vp} = Vapor pressure of fluid at flowing temperature (from standard thermodynamic database, e.g., NIST)

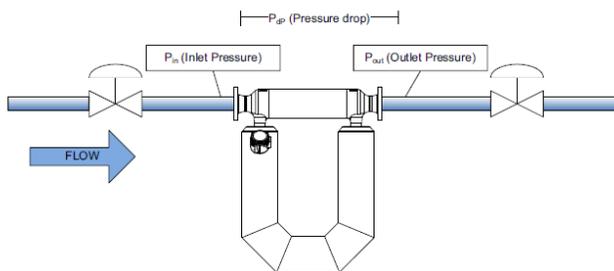


Fig. 1: Pressure drop across sensor

3. Field zeroing of cryogenic meters may improve measurement performance.

For most Coriolis applications, the factory zero is recommended. For applications where operating temperature is significantly different from ambient temperature, a field zero may offer enhanced measurement accuracy. The only field zeroing procedure that is possible is an off-line calculation of zero from the temperature and manual data input to the electronics.

4. Density measurement is usually not required.

Cryogenics are typically bought and sold via mass (standard volume). Therefore, if a Coriolis sensor is implemented, flowing density is rarely a variable of interest. However, if flowing density is desired, additional steps may be required during commissioning. The use of density is an application diagnostic and can tell the user how much flashing they are experiencing. This is the first place to start if the application

flow rates are not correct.

Micro Motion meters measure the flowing density by relating the vibrating tube frequency on air and water at room temperatures to the observed tube frequency under test conditions. When extrapolating to cryogenics, very small errors in temperature measurement propagate through the measurement methodology, resulting in large variations in density measurement. Users should be aware that this typically renders the density measurement unusable. However, the density value can provide valuable insight in a broad fashion as to the overall state of the fluid, e.g., as an indicator of possible flashing.

5. Insulation of the meter is not required.

From the standpoint of flowmeter performance, no insulation of the sensor is required. It is often best to allow the sensor to “ice ball.” With the exception of the cast manifold assembly, a Micro Motion ELITE sensor is already well insulated. The inert-filled secondary containment compartment is similar in construction to the vacuum-jacketed piping commonly used in these applications. Before insulating the Micro Motion sensor, the user should ensure that all surrounding piping has already been insulated. The potential heat loss from surrounding non-insulated piping is far greater than that for the non-insulated Micro Motion sensor.

If all other piping has been insulated and heat loss is still a concern, then insulation of the manifold areas can be considered. Consult a representative of an Industrial Gas Company for recommendations for insulation options.

6. Engineered to Order (ETOs) for cryogenic applications.

Several ETOs are available to maintain performance for varying cryogenic applications:

- ETO 16877 - This ETO specifies the build of the sensor without the use of a conductivity compound which could cause issues at cryogenic temperatures.
- *Dispensing modifications* - For applications with consistent cycling of temperatures from cryogenic to ambient (e.g. some dispensing applications), other modifications may be necessary. Contact Micro Motion support for details on any additional ETO needed for this.

Consult with Micro Motion support to determine if a special ETO or model option should be used for your application.

Frequently asked questions

1. *What is the expected accuracy of mass flow measurement in cryogenic applications?*

The liquid accuracy specification for ELITE sensors does not apply at cryogenic temperatures. Customers should expect performance to fall within the gas accuracy specification. The mass flow accuracy specification for gas is $\pm 0.35\%$ of rate, using an ELITE sensor with MVD-based electronics. Consult the factory for additional information on performance of sensors in cryogenic applications.

2. *Do the area classification approvals apply at cryogenic temperatures?*

For CSA, CSA-US, and UL, the approvals apply because a low temperature limit is not set for fluid temperature.

For ATEX, IECEx, and NEPSI, the standard low temperature limit is above cryogenic limits. However, for sensors ordered with the IIC approval option (Codes 6, 7, and 8, available only for specific models), the low temperature limit is -240°C .

3. *Are purge connections needed to prevent condensation on coils?*

No. Micro Motion does not recommend using purge connections, because field experience has shown that they can allow moisture in the sensor case. Moisture in the case, under cryogenic conditions, can freeze and cause measurement performance and/or accuracy problems.

4. *What gas is used to purge the secondary containment?*

All sensors are purged with an inert gas to ensure a good hermetic, dry seal for the electronic components. Nitrogen or argon is typical.

5. *Does the sensor need to be insulated?*

As discussed previously, the sensor does not need to be insulated. If for some reason insulation is installed, a fabric jacket should not be used for cryogenic applications under any circumstances. The material used in fabric jackets product is intended for use with warm applications. If used with cryogenic applications, the material would simply retain water, get soggy, and freeze. Consult a representative of an Industrial Gas Company for insulation recommendations.

6. *Can I use a Micro Motion D, F-Series, T-Series, H-Series, or R-Series sensor as a lower-cost alternative?*

The Micro Motion ELITE sensor is the only sensor that is lab-tested and has electrical approvals for use in cryogenic service. The Micro Motion ELITE meter with MVD electronics

is the recommended product for handling the accuracy, pressure drop, turndown, and reliability requirements of cryogenic liquid applications.

In some particular situations F-Series may be an option, for example certain MID systems for truck-mounted use. However, for the majority of cryogenic applications the ELITE sensor will be the best choice for measurement.

7. *In cases where a Micro Motion flow measurement solution cannot be found, what other flow measurement technologies can be used to measure cryogenic fluids?*

A Rosemount 8800 Vortex flowmeter or a Daniel Liquid Ultrasonic Flow Meter with Cryogenic Option could be alternatives for measuring the flow of cryogenic liquids. However, these are both volumetric devices and may require compensation for variation in operating density.

Summary

A Micro Motion ELITE sensor, paired with MVD-enabled electronics and sized to control pressure drop, provides reliable and accurate mass flow measurement for cryogenics. A field zero may enhance accuracy. Flowing density measurement, although more difficult, is also possible. Micro Motion can provide site-specific recommendations to help attain the highest possible accuracy.

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