# Rosemount™ Compact Flow Meter Performance in Cryogenic Applications

Recent testing shows standard Rosemount Compact Flow Meter configurations to be accurate and reliable in cryogenic liquid metering. This testing at the NIST (National Institute of Standards and Technology) Cryogenic Flow Measurement Facility proves the performance of the meter in cryogenic applications.

## 1.0 Background

Industrial gases are often moved or stored in a cryogenic liquid state, that is, at cold temperatures and pressures slightly above vapor pressure. In addition to industrial gases, natural gas is now often liquefied (referred to as LNG) and transported great distances to market. Flow metering in these conditions presents special challenges, the solutions to which are the subject of this paper.

At cryogenic conditions, these liquids provide little lubrication for moving parts and therefore create major challenges for traditional turbine and positive displacement flow meters. Additionally, the large temperature gradient presents concerns when O-rings, glands, welds, or dissimilar metals are present in the flow stream. As a result, reliable measurement of cryogenic liquids is difficult with traditional flow metering technologies.

Emerson's Rosemount Compact Flow Meter Series and 405 Compact Primary Elements are well-suited to the measurement of cryogenic liquids because there are no welds in the flow stream and the integral neck tube removes the transmitter from direct contact with the cryogenic liquid.

*Rosemount 3051SFC Compact Conditioning Orifice Plate Flow Meter*

## 2.0 Flow lab information

National Institute of Standards and Technology

Cryogenic Flow Measurement Facility (CFMF)

325 Broadway

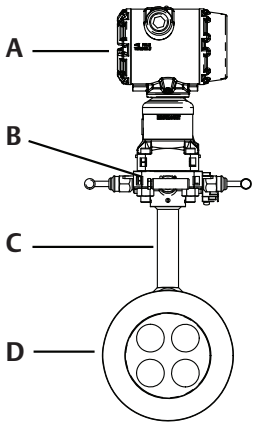
Boulder, CO 80302

## 3.0 Testing and discussion of results

A Rosemount 3051SFC Compact Conditioning Flow Meter was installed and tested in the NIST laboratory cryogenic flow loop located in Boulder, Colorado. Two Rosemount 3051S DP Transmitters were also used and remote mounted for comparison. The lab uses liquid nitrogen (LN2) as a flowing media, with a boiling point of 77 K (-321 °F or -196 °C). This provides a good comparison to performance in Liquefied Natural Gas (LNG) since LNG has a boiling point of 111 °K (-259 °F or -161 °C). A flow calibration was performed to determine the performance of the flow meter in cryogenic service. Figure 1-2 shows the results were excellent, and the meter performed to its standard specification. All data points lie within an uncertainty (or accuracy) band of ±0.75% which is

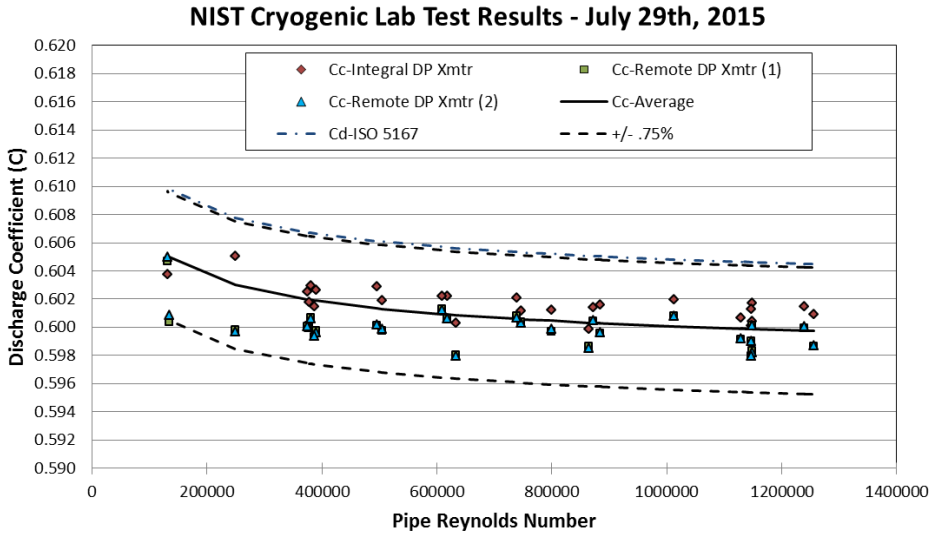
better than the documented uncertainty of this product (±1.0%), and repeat data points taken show excellent repeatability and meet the product specification of ±0.1%.

**Figure 1-1. Major Components–Rosemount 3051SFC Flow Meter**



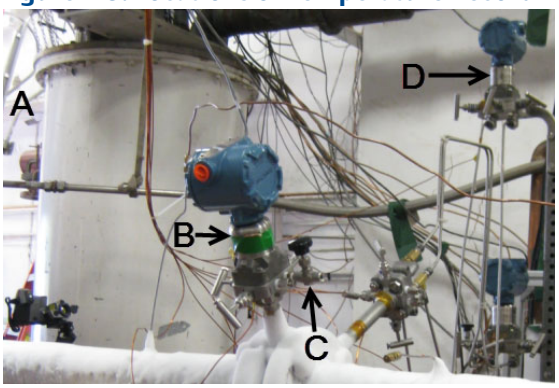

A. Differential pressure transmitter
B. Integral head
C. Neck
D. Conditioning orifice

**Figure 1-2. Discharge Coefficient vs. Reynolds Number**




During the flow calibration, temperature readings were also taken from various points on the meter to determine the ideal orientation as well as to prove that the transmitter remains in the operable temperature range while installed in cryogenic flow. Under ambient conditions of 77 °F (25 °C), the integrally mounted transmitter remained at or above 60 °F (16 °C) as shown on the graph below. During testing, temperatures were recorded at the locations noted in Figure 1-3.

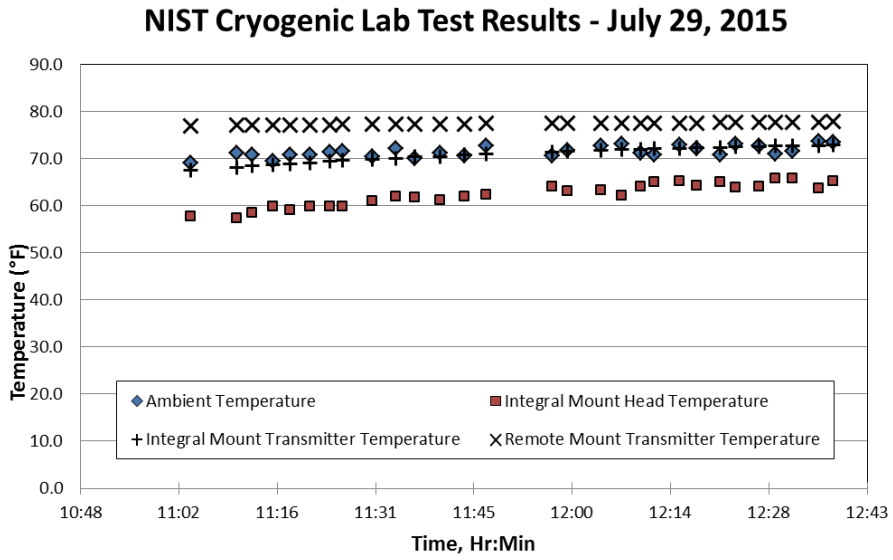
**Figure 1-3. Locations of Temperature Recordings**




A. Ambient temperature
B. Integral mount transmitter temperature
C. Integral mount head temperature
D. Remote mount transmitter temperature

From these results, a minimum safe ambient operating temperature of 40 °F (4 °C) is expected. Below this temperature, provisions should be made with either heat tracing or a heated enclosure to maintain this temperature at the transmitter.

**Figure 1-4. Time vs. Transmitter Temperature**



# 4.0 Installation best practices

- No special materials for O-rings or transmitter diaphragms are required.
- To ensure a gas barrier between the transmitter and cryogenic liquid, the flow meter should be mounted within 45° of the top of the pipe for horizontal flow. This would be between the 10 o'clock and 2 o'clock positions. Vertical flow orientations are not recommended unless the transmitter is remotely mounted.
- The flow meter can be used down to ambient temperatures of 40 °F (4 °C) provided the head and neck are uninsulated. Below this temperature, provisions should be made to maintain the temperature of the transmitter above 40 °F.


*FLIR image of flow meter during cryogenic testing*

- If the piping is insulated, the neck of the flow meter and transmitter should remain uninsulated to maintain a proper operating temperature.
- For remote mounting, ¼-in. tubing should be used and the transmitter mounted at least 12 inches above the primary element.

# 5.0 Conclusion

When used according to this note's installation best practices, the Rosemount 3051SFC will perform to its documented specifications in cryogenic liquids without any modifications to the standard product. Cryogenic liquids included in this statement are Liquid Nitrogen (LN2), Liquefied Natural Gas (LNG), and Liquid Argon (LAR). For other gases not listed above, such as Oxygen (LOX), consult your local Emerson Representative.

# 6.0 Other resources

The ability to handle cryogenic liquids is just one of the many benefits of using Rosemount Differential Pressure Flow Meters to help improve performance of your operation. To learn more about these benefits, contact your local Emerson Representative or visit Emerson.com/RosemountDPFlow.

## Emerson Automation Solutions
6021 Innovation Blvd.
Shakopee, MN 55379, USA
+1 800 999 9307 or +1 952 906 8888
+1 952 949 7001
RFQ.RMD-RCC@Emerson.com

## North America Regional Office
**Emerson Automation Solutions**
8200 Market Blvd.
Chanhassen, MN 55317, USA
+1 800 999 9307 or +1 952 906 8888
+1 952 949 7001
RMT-NA.RCCRFQ@Emerson.com

## Latin America Regional Office
**Emerson Automation Solutions**
1300 Concord Terrace, Suite 400
Sunrise, FL 33323, USA
+1 954 846 5030
+1 954 846 5121
RFQ.RMD-RCC@Emerson.com

## Europe Regional Office
**Emerson Automation Solutions**
Neuhofstrasse 19a P.O. Box 1046
CH 6340 Baar
Switzerland
+41 (0) 41 768 6111
+41 (0) 41 768 6300
RFQ.RMD-RCC@Emerson.com

## Asia Pacific Regional Office
**Emerson Automation Solutions**
1 Pandan Crescent
Singapore 128461
+65 6777 8211
+65 6777 0947
Enquiries@AP.Emerson.com

## Middle East and Africa Regional Office
**Emerson Automation Solutions**
Emerson FZE P.O. Box 17033
Jebel Ali Free Zone - South 2
Dubai, United Arab Emirates
+971 4 8118100
+971 4 8865465
RFQ.RMTMEA@Emerson.com

Linkedin.com/company/Emerson-Automation-Solutions

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