FUNDAMENTAL PRINCIPLES OF ROTARY METERS

John Michalak

Romet International, Ltd.
1080 Matheson Boulevard, East
Mississagua, Ontario
Canada L4W 2V2

INTRODUCTION

Rotary gas meters have been in use for over sixty years in the natural gas distribution industry. Over the years, the construction has switched from heavy cast iron bodies to lighter, high strength aluminum. Advances in manufacturing techniques such as CNC machining centers have enhanced the measurement performance of the rotary meter.

Traditionally rotary meters are installed on applications requiring a flow capacity of 1,000 to 38,000 cfh.

PRINCIPLES OF OPERATION

Rotary gas meters measure the gas by positively displacing or capturing the gas in a measurement chamber. Gas entering the inlet of the rotary meter pressure body produces a differential pressure across the meter, which causes the two impellers to rotate (see Figure 1). The timing gears synchronize the impellers to turn in opposing directions. Each rotation of the impellers measures four displaced volumes of the gas.

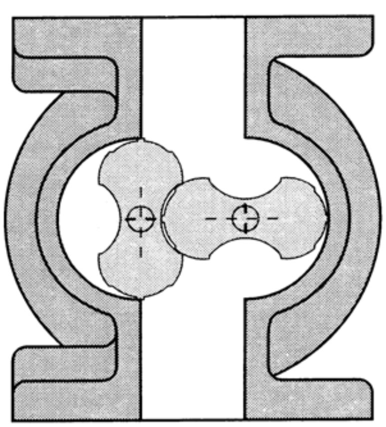

Figure 1. Cutaway View of Meter Housing and Rotors (flow is in the vertical direction).

The meter module converts the rotation of the impellers into standard non-compensated (NC) units of volume that, depending on the module type, may also convert the NC volume to standard base temperature and/or pressure conditions. This converted or compensated volume is what is used for the measurement of the custody transfer or billing of the gas. The related specifications for the measurement of the custody transfer of gas are regulated and enforced by the gas regulatory departments in your area.

METER TYPES

Rotary gas meters are available in several pressure ratings and with a variety of module types to meet the diverse requirements of the gas industry. This paper will only address the most commonly installed rotary gas distribution system. These meters typically have a 175 psig or 12 bar maximum allowable operating pressure (MAOP) and an ANSI 125 flange connection.

Standard Counter Module

The Standard Counter Module registers actual gas volume only and makes no adjustments or corrections to the readings. The Standard Counter Module is available in side-read (see Figure 2) and end-read configurations.

Figure 2. Example Standard Counter Module

Temperature Compensated (TC) Counter Module

Since the temperature of the natural gas may vary substantially from the base temperature (i.e., 60°F or 15°C), the measurement of the custody transfer of natural gas is converted to a volumetric equivalent of this base temperature condition. The temperature compensation (TC) module (see Figure 3) measures the gas temperature with a bi-metallic probe and converts the non-compensated (NC) volume mechanically through a combination of a temperature cam and striker lever assembly.

Figure 3. Example Temperature Compensated (TC) Counter Module

<u>Electronically Compensated Module (ECM2®)</u>

The electronically compensated module (ECM) (see Figure 4) employs a solid-state sensor to sense the rotation of the impellers and produce a high-resolution input (three pulses per impeller rotation) of the non-compensated (NC) metered gas volume. These volumetric input pulses are converted to the base temperature condition (i.e., 60°F or 15°C), using the programmed routines in the microprocessor and the temperature value from the sensor, to perform the necessary calculations.

Figure 4. Example Electronically Compensated Module (ECM2®)

<u>Instrument Drive (STD ID or DCID) Module</u>

Instrument drive (ID) meters (see Figure 5) permit the mounting of a variety of mechanical or electronic (electronic volume correctors) conversion devices. The instrument drive rotation provides a specific non-compensated volume per rotation to the instrument.

Figure 5. Example Instrument Drive (STD ID or DCID) Module

<u>Temperature Compensated Instrument Drive (TCID) Module</u>

Temperature compensated instrument drive (TCID) meters (see Figure 6) convert the non-compensated volume to a volume converted to the base temperature (i.e., 60°F or 15°C) condition and provide this compensation volume through the instrument drive. The instrument drive rotation provides a specific temperature compensated volume per rotation to the instrument.

Figure 6. Example Temperature Compensated Instrument Drive (TCID) Module

ACCURACY

A rotary meter provides accurate gas measurement over a wide range of flow rates within its rated capacity. The following graph illustrates the typical accuracy curve for a rotary meter.

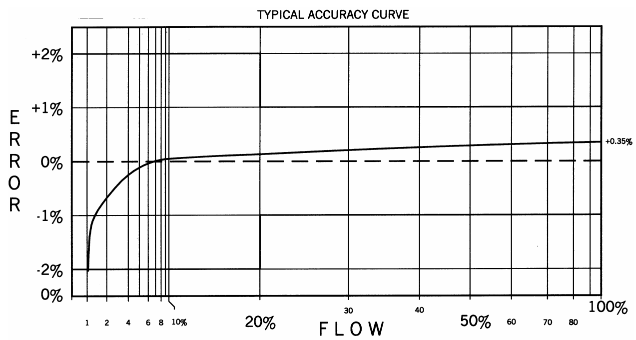

Figure 7. Example Measurement Accuracy Curve

CAPACITY

The maximum rated capacity of a rotary gas meter (Q_{max}) is marked on the meter. This rating is indicated in actual units of volume (e.g., acfh or acmh), since rotary meters measure gas by positive displacement. Natural gas is measured in standard units of volume (e.g., scfh or scmh). The standard unit of volume is simply the volume of gas after being converted to the base conditions. The following formula is employed to correctly size a rotary meter to the flow requirement.

$$Q_{max} = \text{Flow (scfh or scmh)} / P_F \times T_F \qquad \text{(Equation 1)}$$

Where the Pressure Factor, P_F, is:

P_F = $(P_{ATM} + P_{ACT}) / P_{BASE}$

P_{ATM} = Atmospheric pressure (psia or abar)
P_{ACT} = Actual gas pressure (psia or abar)
P_{BASE} = Base pressure (psia or abar)

And where the Temperature Factor, T_F, is:

T_F = $T_{ABS} + T_{BASE} / T_{ABS} + T_{ACT}$

T_{ABS} = 459.67°F or 273.15°C
T_{BASE} = 60°F or 15°C

T_{ACT} = Actual gas temperature °F/°C

<u>Example</u>

The maximum flow requirement for a factory is 40,000 scfh at 40 psig. The peak load occurs in the winter time, when the average flowing temperature of the gas is 38°F.

P_F = (14.65 40) / 14.73
 = 3.71

T_F = 459.67 + 60 / 459.67 + 38
 = 1.04

Q_{max} = 40,000 / 3.71 x 1.04 = 10367 acfh

Therefore, the recommended meter would be and RM11000 with a maximum flow capacity of 11,000 acfh.

TESTING

The verification of a rotary meter body is performed at two flow rates with an allowable error of ±1%.

- 95% ±5% of the meter capacity
- 20% ±5% of the meter capacity

The verification of the meter body accuracy is performed using a certified prover system. The two main types of systems currently employed are:

- Bell
- Transfer

A bell prover determines the meter accuracy by comparing the known volume of the bell to the registered volume of the rotary meter. By measuring the travel of the bell, the volume being passed through the meter is determined and compared to the registered volume from the meter.

A transfer prover verifies the accuracy of the test meter by comparing the known volume passed through the master meter of the prover to the volume registered by the test meter. The flow for the prover is produced by a fan with a motor control to adjust the flow rate.

If the rotary meter has a temperature conversion module, the accuracy of the module must also be verified. In the case of mechanical (TC) modules, the temperature conversion accuracy is verified at three temperatures (i.e., 32, 60, and 86°F or 0, 15, and 30°C) for a specific test volume. Electronic temperature conversion modules (ECM2®) require the verification of the temperature sensor accuracy at the above three test points and a temperature conversion test at only one temperature. In all of the tests, the allowable error is ±1%.

GENERAL INSTALLATION PRACTICES FOR MECHANICAL AND ELECTRONIC ROTARY METERS

Remember that a rotary meter represents a substantial cash register for a gas utility. Good installation practices are the key to obtaining the accurate gas measurement.

Rotary gas meters can be installed in either a horizontal or vertical pipe (see Figure 8). The recommended installation is in a vertical pipe to permit any contaminants in the gas to pass through the meter with the minimum of damage.

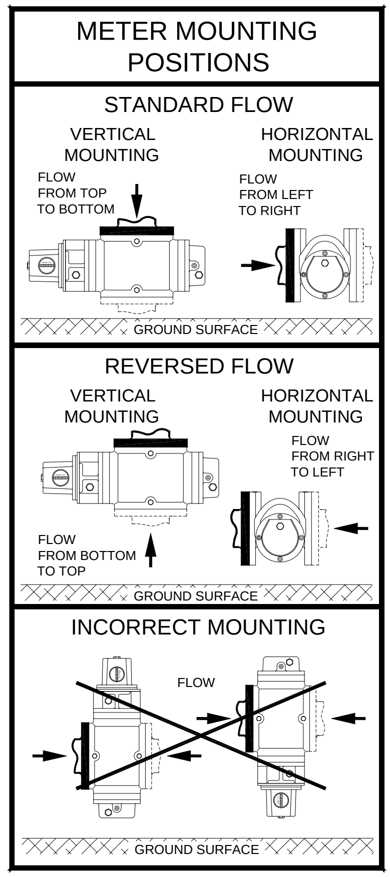

Figure 8. Example Meter Mounting Positions

FIELD INSPECTION AND PRE-INSTALLATION PROCEDURE

Prior to installing a rotary meter, one should inspect for any damage that may have occurred during transport to the site. Remove the protective plugs from the inlet and outlet of the meter. Blowing into the meter will confirm that the impellers are rotating freely and without resistance. Ensure that the piping manifold of the meter station is free of foreign material (e.g., dirt, tap shavings, pipe dope, weld slag, etc.) and scale. Strainers and filters are recommended upstream of the meter to ensure proper gas quality. Check that the mounting flanges for the meter are level (within ±1/16” per foot or 5 mm per meter), parallel to each other and the correct F_L distance apart (see Figure 9 and Table 1).

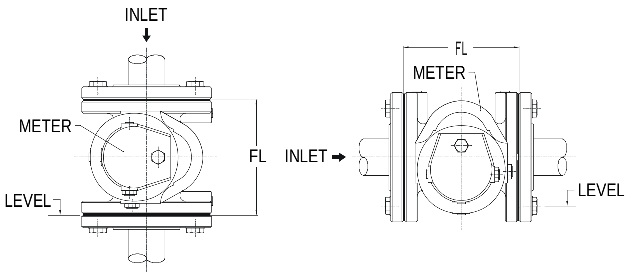

Figure 9. Proper Leveling of a Meter During Installation

Table 1. Flange Separation Distance for Proper Installation

Meter Model	F_L
RM1000-RM5000	6-15/16"
RM7000-RM23000	9-11/16"
RM30-RM140	176 mm
RM200-RM650	246 mm

INSTALLATION

The manufacturer's recommended hardware specifications relating to the mounting flanges and flange bolts, washers, and gaskets should be checked for compliance.

*The dimension between the pipe flanges should equal the meter dimension plus two times gasket thickness.

Install the rotary meter with full-face flange gaskets. Tighten the flange bolts to the manufacturer's recommended torque value. Install the meter oil supplied by the manufacturer as required: ½ way on sight glass.

*Note: Gasket thickness may vary.

PRESSURIZE THE METER

Ensure all oil plugs (and any other connections) are properly tightened and secured before pressurizing the meter set.

When the meter installation has been completed, the meter set should be pressurized SLOWLY (maximum 5 psig or 35 kPa per second) up to the allowable operating pressure specified to avoid over-speed or slamming of the meter. Should the installation be subject to sudden "INSTANT ON-OFF" loads, a properly-sized restricting orifice or Venturi flow nozzle should be installed downstream of the meter to protect the meter from damage.

Check for any gas leaks or other possible problems.

After start up, the readout counter or drive should be running smoothly and in the correct direction when the required gas flow rate has been reached.

MAINTENANCE

Under normal operating conditions, the oil should be inspected every 5 to 10 years and changed or "topped up," as required (see Figure 10). The change period will vary with the cleanliness of the gas being measured.

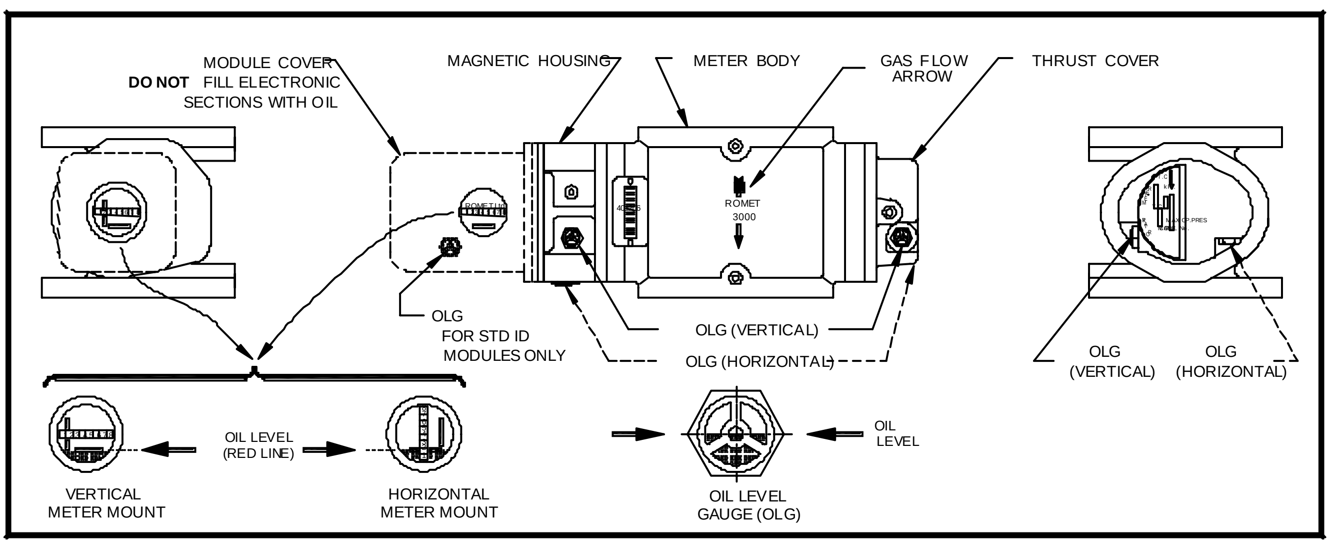

Figure 10. Meter Lubrication Information