ADVANCED APPLICATION OF ROTARY METERS

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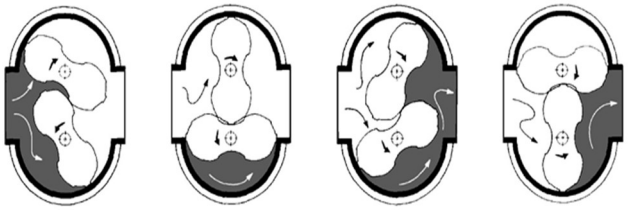
This paper will examine and explain several common characteristics of rotary meters and their use in the natural gas distribution, transmission and production markets. The selection, proper installation, start-up procedures and regular maintenance routines will be covered, as well.

ROTARY METER OPERATING PRINCIPLE



As gas flows through a rotary meter the impellers turn, trapping known volumes of gas. This measuring chamber and impellers are constructed of hard coated anodized aluminum to offer strength and resistance to damage from gas flow debris. For the purposes of this paper it is important to note that the impellers and cylinder do not touch each other and are separated by gaps that measure an average of .003". As a meter begins to increase its speed this gap creates a fluidic seal so that any 'slippage' (unmeasured gas), is confined to very low flow rates.

SIZING ROTARY METERS

The simplest method to select a rotary meter is to add together the total connected load at the minimum pressure. However, it is common to apply diversity factors to that total load in consideration that all gas burning appliances at a location may not be in use at one time.

Rotary meters are designed to be used at 100% capacity. In fact, many sizes of rotary meters will allow a small percentage of over-speed use on an intermittent basis. This ability varies by meter size or type and should be confirmed by the manufacturer. If the meter is going to be subject to over-speed on a regular basis, it is wise to use the next larger size meter.

If a meter could be subject to severe over-speed the user should consider the use of a restricting orifice plate. These plates typically are sized to ensure the meter will not be faced with excessive flows that may cause permanent damage or accelerated wear.

It is also necessary to size the meter so that it sees a minimal amount of flow on a regular basis. This is required to allow the internal splash lubrication system, designed to clean and lubricate the bearings, to work effectively. A flow rate of 10% to 20% of a meter's rated capacity every week or so will allow for the lubrication system to operate.

RANGEABILITY

Rangeability measures the ability of a rotary meter to accurately perform throughout its rated capacity. Rangeability varies by meter size and is calculated by dividing the capacity of the meter by the flow rate at which the accuracy of the meter falls outside a specific accuracy point. Depending on the end user the accuracy limits can be +/-1% or +/-2%.

Some users also consider operational rangeability which is the flow rate where any meter registration will be achieved.

The following is published rangeability data for a popular make of rotary meter:

Meter Size	Rangeability @ +/- 1%	Rangeability @ +/- 2%	Operational Rangeability
8C	26:1	46:1	286:1
15C	40:1	78:1	789:1
2M	68:1	126:1	1053:1
3M	76:1	139:1	1429:1
5M	120:1	215:1	4167:1
7M	67:1	115:1	1321:1
11M	124:1	227:1	2821:1
16M	116:1	223:1	5000:1

If we look at the rangeability of a 5M meter, we can calculate:

Meter Capacity	5000 CFH
+/- 1%	42 CFH thru 5000CFH
+/- 2%	23 CFH thru 5000 CFH
Operational	1.2 CFH thru 5000 CFH

Rotary meter manufacturers have traditionally published rangeability data so that gas utilities can select a meter with the confidence they will measure gas accurately throughout a wide variety of operating conditions, i.e. seasonal or daily heating and processing loads, gas equipment diversity factors and so on.

Meter rangeability has also been improved two ways with the expanded use of integral electronic indexes. The electronic index offers less resistance torque than a traditional mechanical index. This reduced drag allows better measurement at lower flow rates.

Above: *A rotary meter with integral electronic index*

Secondly, some integral electronic indexes can be paired with the meter size by use of an optional trim table. The trim table adjusts the value of input pulses at low flow rates to remove the inherent inaccuracy. The trim table can be configured in such a way as to increase rotary meter rangeability to 333:1 at +/-1% accuracy.

START RATES

Not surprisingly, the start rate for a meter is the flow rate at which a meter will begin – and continue- to turn. While accuracy at these start rates can vary widely, it is generally between 70% and 90%. The ANSI B109.3 standard, which governs the performance of rotary gas meters specifies that meters must have a start rate no higher than 0.5%of the rated capacity. The start rate data for the same family of meters listed in the rangeability section is shown below:

Meter Size	Operational Rangeability	MFR. Start Rate (CFH)	ANSI Req'mt. (CFH)
8C	286:1	2.8	4
15C	789:1	1.9	7.5
2M	1053:1	1.9	10
3M	1429:1	2.1	15
5M	4167:1	1.2	25
7M	1321:1	5.3	35
11M	2821:1	3.9	55
16M	5000:1	3.2	80

Meter manufacturers must use precision, lab quality measurement equipment to perform the

many tests required to obtain this data. This test equipment often includes:

- Laminar flow element
- Liquid manometer
- Rheostat
- Cadillac blower
- Barometer
- Thermometer
- Timer
- Associated piping and connectors

Once the test equipment is assembled the meter is subjected to very low flows until the low limit is reached where the meter will start to turn, and *continue to turn for two minutes.* Manufacturers run these tests multiple times to prove out the design and be confident in their published data.

STOP RATES

Once the gas flow has overcome the mechanical forces to get a meter turning, the rate of flow when a meter will stop is lower still. Rotary meter manufacturers also publish this data.

STARTING AND RUNNING DIFFERENTIAL

The differential, or pressure drop, across a rotary meter is an important component of the design criteria. Low differential rates indicate all meter parts are working efficiently and friction within the meter is at a minimum. Manufacturers are required to test for starting differential by ANSI B109.3 standards. Additionally the manufacturer is required to publish typical differential values for a running meter. Running differential is important in that many gas utilities and other users of rotary meters use differential pressure testing to verify the condition of the meter. Differential testing requires that the pressure drop across a meter be determined at time of installation to set the base line to which subsequent tests are compared. The basic rule-of-thumb for differential testing is to address the condition of a meter when the differential across a meter has increased 50% or more.

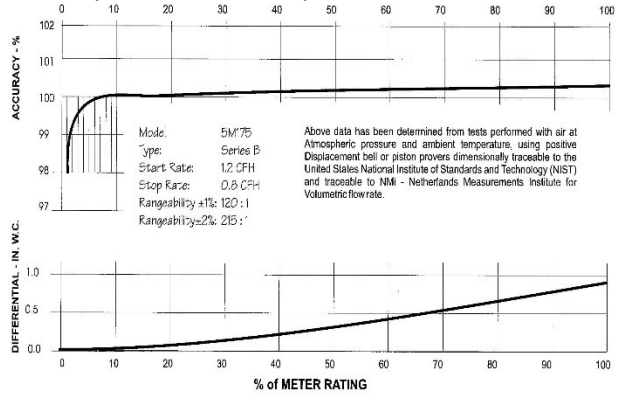
METER ACCURACY

The ANSI B109.3 standard for rotary meters mandates that new meters meet an accuracy range of +/- 1% at flow rates representing 10% through 100% of the meter's rated capacity. The ANSI B109.3 further requires that meter manufacturers perform an accelerated life test. This accelerated life test consists of meters running at 100% of rated capacity for 4,000 hours. At the end of this test the meter must still be accurate to +/-1% at 10% through 100% of capacity. The chart below illustrates initial and sustained accuracy for meters from one vendor.

METER SIZE	INTIAL ACCURACY		SUSTAINED ACCURACY	
	10%	100%	10%	100%
8C	99.33	100.09	99.61	100.25
15C	99.55	100.13	99.55	100.22
2M	99.60	100.04	99.65	100.20
3M	100.10	100.34	99.97	100.22
5M	100.21	100.54	100.15	100.54
7M	100.30	100.45	100.27	100.59
11M	100.04	100.36	100.00	100.50
16M	100.24	100.60	100.21	100.74

The initial and sustained accuracy of rotary meters have led gas utilities and other users to have confidence that the rotary meter they select will maintain its performance levels for a long time. Likewise, manufacturers of rotary meters can claim, also confidently, that a rotary meter has a fixed and permanent accuracy.

Manufacturers of rotary meters publish typical accuracy and differential pressure curves.



As expected, this curve illustrates the meter accuracy is well within the +/-1% range specified by the ANSI standard for flow rates between 10% and 100% of meter capacity.
Manufacturers have also proven overall meter accuracy at a wide variety of flow rates. This "day-after-day" accuracy has given users confidence that the meter they have selected will measure a very high percentage of the actual flow even if the meter sees very low flow periodically. The gas utility engineer still must size the meter to its optimum performance, but gas loss at very low flows is of little concern as the meter runs slightly fast at higher flow rates to compensate for this loss. Consider the following example:

24 HR. OVERALL ACCURACY FOR RESTAURANT

METER SIZE: 15C175
LINE PRESSURE: 10 PSIG

Flow Rate (ACFH)	Hours	Actual Volume (SCFH)	Accuracy (%)	Measured Volume (SCFH)
800	4	5301	100.18	5310
250	4	1656	99.98	1656
100	3	497	99.55	495
35	5	290	98.33	285
1	8	13	0.00	0

Total Measured Volume: 7,746 SCF
Total Actual Volume: 7,757 SCF
OVERALL ACCURACY: 99.86%

It certainly is not necessary to examine each application in such detail. The above case study is merely an illustration of the ability of rotary meters to accurately register gas usage across a wide range of flow conditions.

INSTALLATION AND START-UP

The rotary meter is a precision measurement device. As such, it is important that precautions be taken at installation to ensure the meter will operate to expectations.

- *Piping stress*
  - Ensure the meter is not subjected to the stress associated with misaligned flanges or other piping discrepancies. Make sure the meter is level to within 1/16th" per foot. Follow the manufacturer torque recommendations.
- *Gas Conditions*
  - Be sure that the meter is protected from debris on the pipeline, such as pipe dope, weld slag, plastic pipe shavings, excessive moisture, etc.
- *Meter placement*
  - Do not have the meter in the low point of the meter set. Mount it above any areas that might collect moisture or debris. Consider mounting the meter in a vertical pipeline so that some small contaminants can fall through the meter.
- *Check for rotation*
  - Prior to start-up, use the access plug on the gear end of the meter to check for smooth rotation of the impellers.
- *Slowly pressurize*
  - Do not exceed 5 psi per second. Severe or sudden pressurization can damage the meter

- *Snap On-Off Loads*
    - Consider the use of a restricting orifice plate to protect the meter against sudden on-off applications.

FIELD MAINTENANCE

There is little maintenance required to keep rotary meters working satisfactorily for many years.

- *Oil Level and Color*
    - Upon inspection ensure the oil is at the proper level, i.e. at the mid-point of the oil sight gauge. DO NOT OVERFILL. Too much oil may enter the measurement chamber and lead to measurement inaccuracies and premature meter maintenance. If the oil is low, top it up slowly. If the oil has become discolored, change it.
- *Differential Pressure Testing*
    - The differential pressure across a rotary meter is a good indication of the condition of the meter body. Most state regulatory commissions recognize differential testing as a sound preventive maintenance practice. Recent advances in electronic instrumentation allow for on-board differential testing coupled with alarm signals triggered by high differential levels.
- *Field Prover Tests*
    - To obtain a test result that includes actual meter accuracy, many gas distribution and transmission companies use a transfer prover. Transfer provers are available in a wide range of capacities and typically are controlled with the manufacturer software.

Above: *Testing a rotary meter with a transfer prover*

- *Temperature Compensated Cycle Test*
    - When a mechanical TC meter needs field verification, one common method is a field cycle test. This test compares the field meter TC index to the theoretical value over a number of compensation cycles

CONCLUSION

Engineers at gas distribution, transmission and production companies have many factors to consider when specifying rotary meters for their systems. When properly applied, they may expect long-term accurate gas measurement.

ABOUT THE AUTHOR

Ron Walker is President and Founder of Walker Technical Sales Inc. Ron has been involved in the North American gas industry for over 35 years and the Appalachian Gas Measurement Short Course since 1994.

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