Gas Turbine Meter Measurement

Wayland Sligh
Daniel Measurement and Control, Inc.
Houston Texas

Introduction

The gas industry has a wide variety of measurement equipment to satisfy nearly every application need. Metering is no exception. The bulk of gas measurement in the U.S. is handled by four basic types of meters: diaphragm, rotary, turbine and orifice meters. In any specific application, there are trade-offs to be made in selecting one type of meter over another. Knowing the strengths and weaknesses of each type of meter is fundamental to the gas measurement engineer or manager of measurement.

Meter Types

The four types of meters mentioned above fall into two general categories. Diaphragm and rotary meters are referred to as positive displacement meters, and turbine and orifice meters are referred to as inferential meters or (velocity meters).

A positive displacement meter contains measurement compartments that alternately fill and empty as the meter rotates. These compartment represent a know quantity of gas.

An inferential meter has no measurement compartments. We infer the volume of gas that has passed through the inferential meter by some physical action. In the case of the orifice meter, the flow is related to the pressure drop across the orifice plate.

In the turbine meter, the volume is proportional to the number of revolutions of the turbine rotor. The rotational speed of the rotor is directly proportional to the velocity of the gas as it passes through the rotor blades.

Operation

As the gas enters the meter inlet, it is forced to flow through a passage created by the inside diameter of the meter body and the outside diameter of the diffuser. This passage has an area equal to about one third the area of the upstream pipe. Therefore, in order for the flow through this restricted area to be equal to the flow through the inlet pipe, the gas velocity must increase by a factor of three. This increase in velocity in turn boosts the kinetic energy of the gas, making more energy available to turn the turbine rotor.

As the gas passes through the turbine rotor, it impinges on the face of the blades, causing the rotor to turn. If the meter was completely frictionless, it would take an extremely small amount of kinetic energy to cause the rotor to begin turning. In a mechanical drive turbine, the blade will begin turning at approximately 1% of the meters maximum capacity. As the gas velocity increases to 10% of the meter's maximum capacity, the available energy to overcome friction and drive the rotor increases and the meter accuracy reaches acceptable limits. In the Daniel electromagnetic turbine, the energy required to turn the rotor is somewhat less because of the lack of retarding forces from the mechanical gears.

Rangeability

A prime characteristic of the turbine meter is its rangeability. This is the ratio of the maximum meter capacity to the minimum capacity for the stated operating conditions to which the turbine meter will retain its specified accuracy. The rangeability of most present day gas turbine meters at atmospheric pressure is 10 to 1 or greater as shown in the table 1 below.

TYPICAL TURBINE METER PERFORMANCE

METER SIZE	MAX. FLOW Rate SCFH	RANGE	MIN. FLOW Rate SCFH	Approx. Differential Inches W.C.
Mini Gas	5900	10:1	590	1.0
4	18,000	15.1	1,200	1.2
6	36,000	15.1	2,300	1.5
8	60,000	20:1	3,000	1.8
12	150,000	20:1	7,500	1.7

Table 1

Meter Capacity

The maximum capacity is determined by such factors as rotor speed, pressure drop, and gas velocity. The limitation of the meter capacity due to rotor speed is a relative matter. The bearings used in the turbine meter have a give life under a given load and at a specific speed. As the speed of the rotor is varied, the life of the bearings varies. Although the turbine meter is capable of turning at three to four times its maximum speed without immediate damage, its life can be substantially reduced if this speed is maintained for prolonged periods.

The pressure drop across the rotor also influences the maximum capacity of the turbine meter. In some applications where line pressures running from 7 to 10 inches of water above atmospheric, the pressure loss caused by measurement equipment must be at a minimum.

The gas velocity becomes a controlling factor due to the aerodynamic characteristics of the rotor blades and also the need to avoid the possibility of obtaining sonic velocity within the meter.

meter manufacturer, based on the bearings that were selected for the meter.

Density

Pressure, temperature, specific gravity and compressibility of the gas all effect the gas density. So as these parameters change to cause an increase in density, the minimum flow rate that is achievable by a gas turbine meter is decreased, increasing the rangeability.

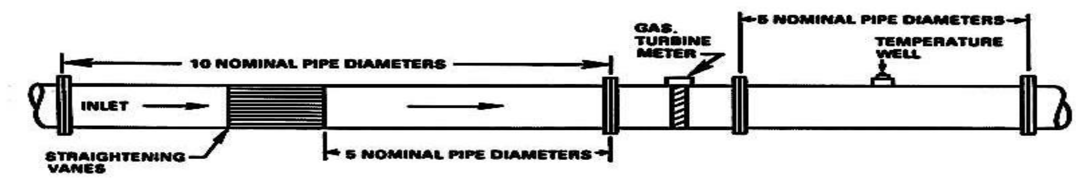
The density of the gas does not affect the maximum rated capacity of a meter. The maximum flow rate is determined by the meter manufacturer, based on the bearings that were selected for the meter.

Installation

Where space permits, a turbine meter installation should include ten diameters of straight piping ahead of the meter with straightening vanes and five diameters of straight piping downstream. An alternative to this is the short-coupled installation.

See figures 1 and 2.

Figure 1.



RECOMMENDED INSTALLATION OF AN IN-LINE GAS TURBINE METER (MINIMUM LENGTHS)