

**OPERATING
SECTION
REPORT**



**American Gas
Association**

**GAS
MEASUREMENT
MANUAL**

GAS TURBINE METERING

PART NO. FOUR

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A.G.A. GAS MEASUREMENT MANUAL (Revised)

PART FOUR GAS TURBINE METERING

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SECTION 4.1—Gas Turbine Metering

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Section 4.1 GAS TURBINE METERING

INTRODUCTION

Scope

This section recommends installation specifications, calibration, testing, applications, operation and maintenance procedures, and computations used in the calculations of flow related to the axial flow type gas turbine meter.

Reference to other documents should be made for discussions of accessory equipment used to measure pressure, temperature, and density of the flowing gas, or for devices to automatically compute volumes at base conditions.

History

The concept of turbine meter measurement is quite old. Although first used with water as the flowing medium in the early 20th century, turbine meters to measure gases were not developed until the early 1950s.

Definition and Theory of Operation

Gas entering the meter increases in velocity as it flows through the annular passage formed by the nose cone or upstream stator and the interior wall of the body. The movement of gas over the angled rotor blades imparts a force to the rotor causing it to rotate. The ideal rotational speed of the rotor is directly proportional to the flow rate. The actual rotational speed of the rotor is a function of the annular passageway size and shape, and the rotor design. It is also dependent upon the load that is imposed due to internal mechanical friction, fluid drag, external loading, and the gas density. (See Figures 4.1.1 and 4.1.1A)

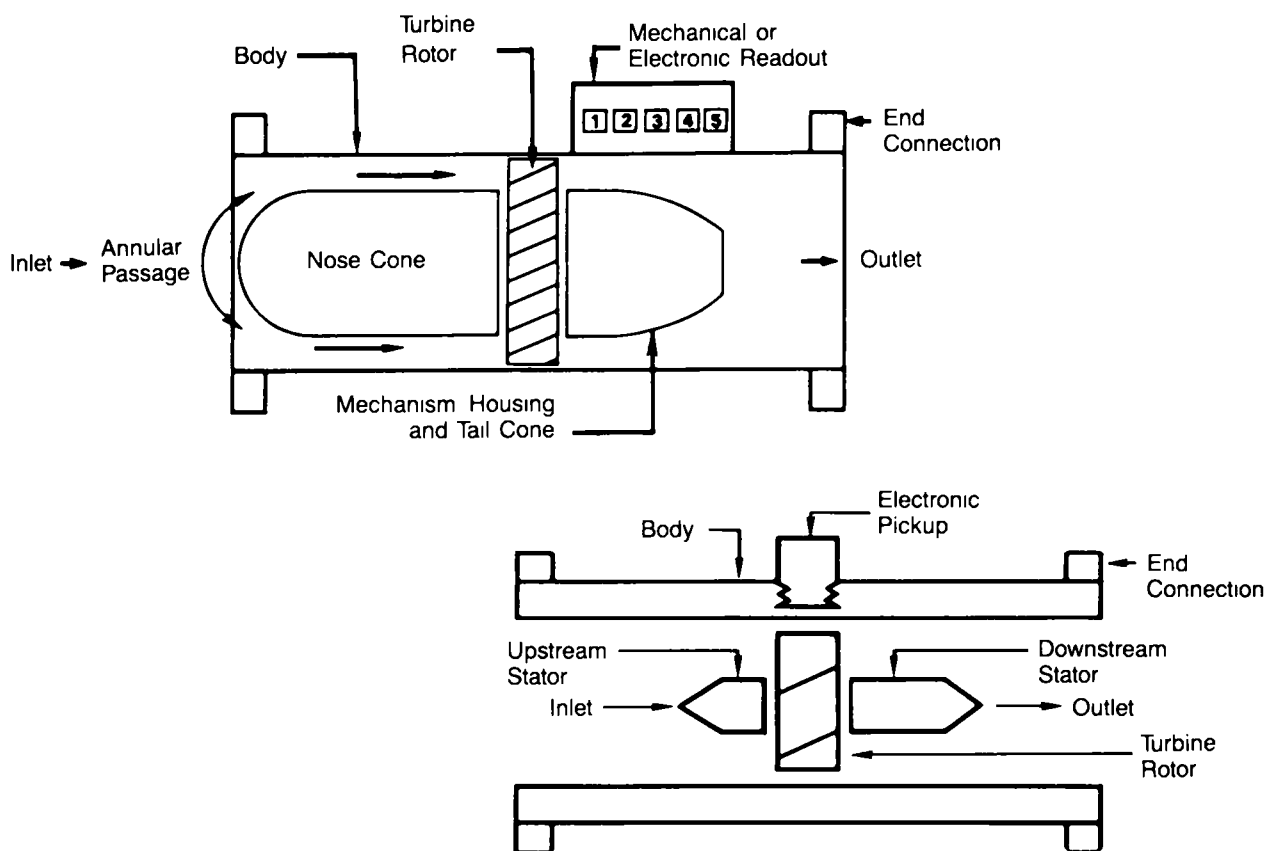


Figure 4.1.1 and Figure 4.1.1A—Schematic Drawings of Axial Flow Gas Turbine Meters

PERFORMANCE CHARACTERISTICS

Rangeability

Rangeability is defined as the ratio of the maximum meter capacity to the minimum capacity within acceptable accuracy parameters for the specified operating conditions. These are usually $\pm 1.0\%$ of reading or better. The turbine meter's rangeability increases with pressure and gas density.

Repeatability

Repeatability is the closeness of agreement of the results of successive measurements of the same operating conditions carried out by the same method, by the same observer, and the same facility with the same instruments. Turbine meters have demonstrated the ability to repeat within $\pm 0.10\%$ on successive short duration test runs and within $\pm 0.15\%$ on a day-to-day basis (tests conducted under identical operating conditions). Good repeatability over longer periods depends on maintaining the physical condition of the meter and comparing periods where the meter is operating under similar flowing conditions.

Accuracy

The accuracy of a meter is the degree of conformity of the indicated value of the meter to the true value of the measured quantity. In the flow measurement of natural gas, the accuracy of a gas turbine meter as indicated by the meter output is generally specified as within $\pm 1.0\%$ of the true volume over a certain specified flow range and pressure range using air as the calibration flow medium. The true volume generally refers to the test volume indicated by the prover used to calibrate the meter. For accuracy better than $\pm 1.0\%$, the manufacturer should be consulted for the specific application or meters should be calibrated against a secondary standard under conditions near the meter's intended operating pressure.

Corrected Volume Computation

In computing corrected volume from uncorrected or index volume measured by a turbine meter, four factors are needed: index volume, pressure correction, temperature correction, supercompressibility factor squared (F_{pv})². These are the same factors used for volume computation of diaphragm and rotary displacement meters.

Capacity

The capacity of a turbine meter in terms of base flow rate increases directly with the absolute flowing pressure.

Pressure Loss

A gas turbine meter has a pressure loss approximately equivalent to an orifice meter equipped with a 0.75 Beta orifice plate where equivalent volumes, pressures, and temperatures are encountered.

Effects of Pulsation

According to W. F. Z. Lee, J. J. Kirik, and J. A. Bonner, *Journal of Engineering for Power*, Trans. ASME, October, 1975, "Gas Turbine Flowmeter Measurement of Pulsating Flow," the meter pulsation error of a gas turbine meter, unlike the orifice meter, depends primarily upon flow fluctuation, not pressure fluctuation. Test results indicate a turbine meter retains its steady-state repeatability in pulsating flow. It is possible to estimate the meter pulsation error for a known pulsating flow situation.

Calibration

Turbine meter manufacturers will predict an accuracy of $\pm 1\%$ over a specified flow range for any operating density. Turbine meters are capable of $\pm 0.25\%$ accuracy over a specified flow range if they are individually calibrated against an acceptable standard at the particular density at which they will be operated. Therefore, the most accurate turbine meter performance is obtained when each meter is calibrated under density conditions approaching the meter's actual operating density. If meter calibration at operating density is impractical, it is necessary to rely on the manufacturer's prediction of the calibration shift to be expected between the calibrating and operating densities.