Manual of Petroleum Measurement Standards Chapter 5—Metering

Section 3—Measurement of Liquid Hydrocarbons by Turbine Meters

FIFTH EDITION, SEPTEMBER 2005

REAFFIRMED: AUGUST 2014

API
American Petroleum Institute

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FOREWORD

Chapter 5 of the API *Manual of Petroleum Measurement Standards* (API *MPMS*) provides recommendations, based on best industry practice, for the custody transfer metering of liquid hydrocarbons. The various sections of this Chapter are intended to be used in conjunction with API *MPMS* Chapter 6 to provide design criteria for custody transfer metering encountered in most aircraft, marine, pipeline, and terminal applications. The information contained in this chapter may also be applied to non-custody transfer metering.

The chapter deals with the principal types of meters currently in use: displacement meters, turbine meters and Coriolis meters. If other types of meters gain wide acceptance for the measurement of liquid hydrocarbon custody transfers, they will be included in subsequent sections of this chapter.

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5.3.1 Introduction

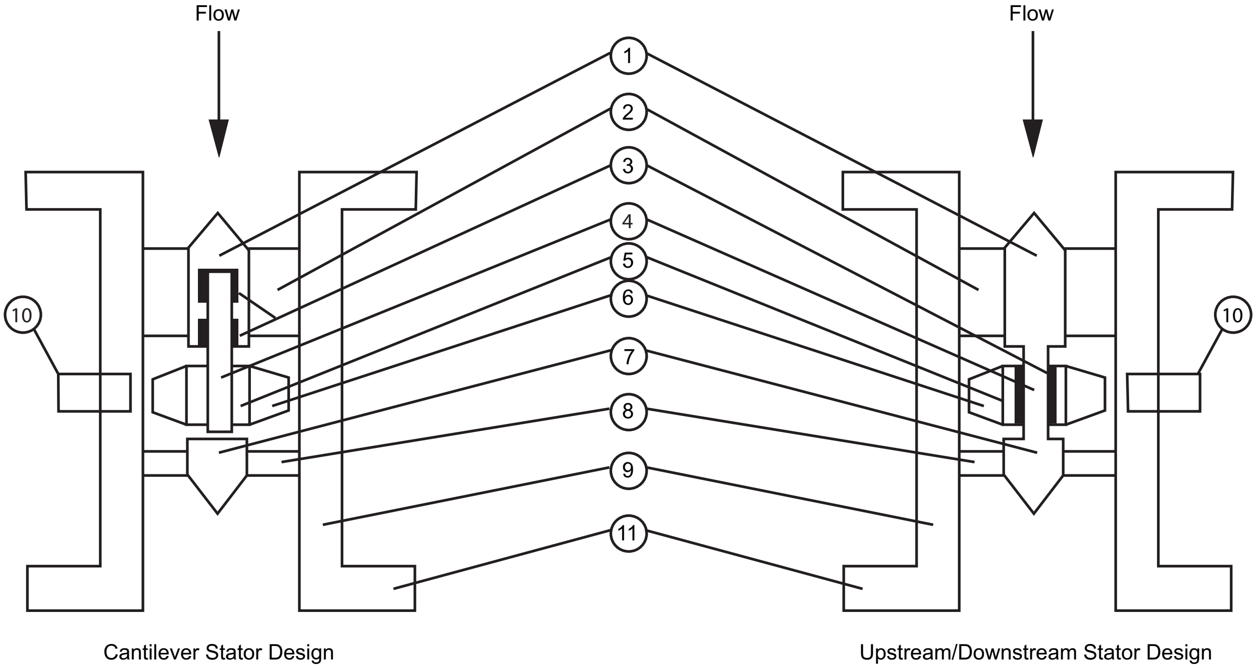
API *MPMS* Chapter 5.3, together with general considerations for measurement by meters in API *MPMS* Chapter 5.1, is intended to describe methods of obtaining accurate quantity measurements with turbine meters in liquid hydrocarbon service.

A turbine meter is a flow-measuring device with a rotor that senses the velocity of flowing liquid in a closed conduit (see Figure 1). The flowing liquid causes the rotor to move with a tangential velocity proportional to the average stream velocity (which is true if the drag on the rotor—mechanical and viscous—is negligible). The average stream velocity is assumed to be proportional to the volumetric flow rate (which is true if the cross-sectional flow area through the rotor remains constant). The movement of the rotor can be detected mechanically, optically, or electrically and is registered. The volume that passes through the meter is determined by proving against a known volume, as discussed in API *MPMS* Chapter 4.

It is recognized that meters other than the types described in Chapter 5.3 are used to meter liquid hydrocarbons. This publication does not endorse or advocate the preferential use of turbine meters, nor does it intend to restrict the development of other types of meters. Those who use other types of meters may find sections of this chapter useful.

5.3.2 Scope

This section of API *MPMS* Chapter 5 covers the unique installation requirements and performance characteristics of turbine meters in liquid-hydrocarbon service.



Notes:

1. Upstream stator.
2. Upstream stator supports.
3. Bearings.
4. Shaft.
5. Rotor hub.
6. Rotor blade.
7. Downstream stator.
8. Downstream stator supports.
9. Meter housing.
10. Pickup.
11. End corrections.

Figure 1—Names of Typical Turbine Meter Parts

5.3.3 Field of Application

The field of application of this section is all segments of the petroleum industry in which dynamic measurement of liquid hydrocarbons is required. This section does not apply to the measurement of two-phase fluids.

5.3.4 Referenced Publications

The current editions of the following API *MPMS* Standards contain information applicable to this chapter:

API
Manual of Petroleum Measurement Standards
Chapter 4, "Proving Systems"
Chapter 5.1, "General Considerations for Measurement by Meters"
Chapter 5.4, "Accessory Equipment for Liquid Meters"
Chapter 5.5, "Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems"
Chapter 7, "Temperature"
Chapter 8, "Sampling"
Chapter 11, "Physical Properties Data"
Chapter 12, "Calculation of Petroleum Quantities"
Chapter 13, "Statistical Aspects of Measuring and Sampling"

5.3.5 Flow Conditioning

5.3.5.1 The performance of turbine meters may be affected by swirl and non-uniform velocity profiles that are induced by upstream and downstream piping configurations, valves, pumps, fittings, joint misalignment, protruding gaskets, welding projections, or other obstructions. Flow conditioning shall be used to overcome the adverse effects of swirl and non-uniform velocity profiles on turbine meter performance.

5.3.5.2 Flow conditioning requires the use of sufficient lengths of straight pipe or a combination of straight pipe and flow conditioning elements that are inserted in the meter run upstream (and downstream, if flow through the meter is bidirectional) of the turbine meter (see Figure 2).

5.3.5.3 When only straight pipe is used, the liquid shear, or internal friction between the liquid and the pipe wall, shall be sufficient to accomplish the required flow conditioning. Appendix A should be referred to for guidance in applying the technique. Experience has shown that in many installations (e.g., downstream of a simple elbow or Tee) a straight pipe length of 20 meter-bore diameters upstream of the meter and 5 meter-bore diameters downstream of the meter often provides effective flow conditioning.

5.3.5.4 For severe swirl, such as generated by two close coupled elbows out-of-plane (i.e., non-symmetrical swirl) or by a header (i.e., dual symmetrical swirl), a straightening element (i.e., swirl breaker) type of flow conditioner is required. These types of swirl are slow to dissipate in straight pipe, often existing after 100+ diameters of straight pipe.

5.3.5.5 A straightening element or swirl-breaker type of flow conditioner usually consists of a cluster of tubes, vanes, or equivalent devices that are inserted longitudinally in a section of straight pipe (see Figure 2). Straightening elements effectively assist flow conditioning by eliminating swirl. Straightening elements may also consist of a series of perforated plates or wire-mesh screens, but these forms normally cause a larger pressure drop than do tubes or vanes.

5.3.5.6 Proper design and construction of the straightening element is important to ensure that swirl is not generated by the straightening element since swirl negates the function of the flow conditioner. The following guidelines are recommended to avoid the generation of swirl:

a. The cross-section should be as uniform and symmetrical as possible.
b. The design and construction should be rugged enough to resist distortion or movement at high flow rates.
c. The general internal construction should be clean and free from welding protrusions and other obstructions.

5.3.5.7 Isolating type flow conditioners, which produce a swirl-free, uniform velocity profile, independent of upstream piping configurations, are typically more sophisticated, expensive and higher pressure drop than simple straightening element type flow conditioners. However, in certain installations, they provide a performance advantage and should be considered.

5.3.5.8 Flanges and gaskets shall be internally aligned, and gaskets shall not protrude into the liquid stream. Meters and the adjoining straightening section shall be concentrically aligned.

5.3.6 Minimum Back Pressure to Prevent Cavitation

In the absence of a manufacturer's recommendation, the numerical value of the minimum back pressure at the outlet of the meter may be calculated with the following expression, which has been commonly used. The calculated back pressure has proven to be adequate in most applications, and it may be conservative for some situations.

$$P_b = 2\Delta p + 1.25 p_e$$