

# Performance of Full-bore Vortex Meters for Measurement of Liquid Flows

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# Contents

Page

1	Scope .....	1
2	References .....	1
3	Terms, Definitions, and Abbreviations .....	1
3.11	Abbreviations.....	2
4	Field of Application .....	2
5	Test Matrix for Full-bore Vortex Meter.....	2
5.1	Baseline Calibration at the Calibration Facility .....	3
5.2	Field Testing of Vortex Meter with Hydrocarbon Fluids .....	4
6	Test Results .....	5
6.1	4-in. (100-mm) Vortex Meter Performance .....	5
7	4-in. (100-mm) Vortex Meter Performance in the Field with Hydrocarbon Fluids .....	8
8	2-in. (50-mm) Vortex Meter Performance .....	14
9	Additional Test Results from Other Standards .....	17
10	Conclusion.....	17
	Annex A (informative) Plots of Baseline Proving Data of 4-in. (100-mm) Vortex Meters .....	18
	Annex B (informative) Experimental Data from OIML D 25 Report .....	21
<b>Figures</b>		
1	Schematic Setup at the Calibration Facility .....	3
2	Calibration Facility Test Setup .....	4
3	Portable Proving Operation in the Field .....	4
4	Typical Shape of a Meter Factor Curve .....	5
5	Composite Plot of Meter Factors (MF) of Five Vortex Meters for Master Meter Proves .....	7
6	Composite Plot of Vortex Meter Repeatability for Master Meter Proves .....	7
7	Composite Plot of Difference in Meter Factor for Five Vortex Meter Data Calibrated by Master Meter and Small Volume Prover .....	8
8	Performance of Meter A and Meter D (Meter Factor vs Flow Rate) for Hydrocarbon Flows .....	11
9	Performance of Meter A and Meter D (Meter Factor vs API Gravity Hydrocarbon Fluid) .....	11
10	Performance of Meter D (Meter Factor vs Flow Rate) for Hydrocarbon Fluids .....	12
11	Performance of Meter D (Meter Factor vs Degree API of Hydrocarbon Fluids) .....	12
12	Meter A Performance at Different Flow Rates .....	13
13	Performance of Meter A (Meter Factor vs Degree API of Hydrocarbon Fluids) .....	13
14	Performance of Meter E (Meter Factor vs Flow Rate) for Hydrocarbon Fluids .....	14
15	Performance of Meter E (Repeatability on Points vs Degree API of the Hydrocarbon Fluid) .....	14
16	Meter Factor vs Flow Rate for 2-in. (50-mm) Meter F .....	15
17	Meter Factor vs Flow Rate for 2-in. (50-mm) Meter G .....	15
18	Meter Factor vs Flow Rate for 2-in. (50-mm) Meter H .....	16
19	Composite Calibration Data of 2-in. (50-mm) Meter F, Meter G, and Meter H Calibrated by Small Volume Prover .....	16
A.1	Meter Factor of Vortex Meter A by SVP and Turbine as the Master Meter .....	18
A.2	Meter Factor of Vortex Meter-B by SVP and Turbine as the Master Meter .....	18
A.3	Meter Factor vs Flow rate of Vortex Meter C by SVP and Turbine as the Master Meter .....	19
A.4	Meter Factor of Vortex Meter D by SVP and Turbine as the Master Meter .....	19

## Contents

	Page
<b>A.5 Meter Factor of Vortex Meter E by SVP and Turbine as the Master Meter</b> .....	<b>20</b>
<b>B.1 Relation between Strouhal Number and Reynolds Number for a Vortex Meter</b> .....	<b>21</b>
<b>B.2 Meter Accuracy vs Reynolds Number</b> .....	<b>21</b>

### Tables

<b>1 Summary Data of all Master Meter Proves at the Calibration Facility</b> .....	<b>6</b>
<b>2 Summary Data of Meter A</b> .....	<b>8</b>
<b>3 Summary Data of Meter B</b> .....	<b>9</b>
<b>4 Summary Data of Meter C</b> .....	<b>9</b>
<b>5 Summary Data of Meter D</b> .....	<b>10</b>
<b>6 Summary Data of Meter E</b> .....	<b>10</b>

## Introduction

This technical report documents performance characteristics of several commercially available vortex meters for liquid flows. Although vortex meters are available in full-bore and reduced-bore designs, performance verification and characterization were limited to full-bore liquid vortex meters only, due to the inadequacy of test data available in the public domain for reduced-bored designs and lack of funding to develop a field test database for hydrocarbon liquids. Vortex meter test results reported in this document are of nominal 2-in. (50-mm) and 4-in. (100-mm) meter sizes. Five vortex meter vendors participated in the laboratory and field tests with hydrocarbon liquid of 4-in. (100-mm) meters, while only three manufacturers participated in the 2-in. (50-mm) tests. Since the flow rate through 2-in. (50-mm) vortex meters is relatively low, its use in field trials with hydrocarbon fluids was not possible, as it would delay and limit the normal operation of the field meter. Therefore, 2-in. (50-mm) vortex meter tests were limited to performance verification at the laboratory test facility with water only.

The baseline performance of each meter was established under controlled flowing conditions of the laboratory test facility, where the test fluid was water. Commercially available 4-in. (100-mm) vortex meters output may have a manufactured pulse, where the pulse output is used during proving of the meter to establish the meter factor and repeatability of the meter factor. Also, due to time variations of shed vortices that result from hydrodynamic instability and current limitations of the available sensor technology, the raw pulse signal of vortex meters require time averaging. The reference flow rate at the proving facility was established by a Small Volume Prover (SVP), also referred to as Captive Displacement Prover (CDP), because proving of field meters for hydrocarbon fluids was performed by portable proving systems that used SVP. The time of the proving run of a SVP normally used to calibrate 4-in. (100-mm) meters was inadequate for the time-averaged proving run required for the flow rate range of the liquid vortex meters. The laboratory proving setup duplicated the portable field proving system. In order to achieve repeatable meter factors (MF) and laboratory and field proving of vortex meters, the MF of the meter being tested was established by utilizing the transfer proving method. The master meter (MM) for the transfer proving was the liquid turbine meter, whose MF was established by the SVP. At the proving facility, the MM, meter being tested, and SVP, were installed in series.

In the field, the performance of the vortex meter for hydrocarbon flows were established against the field flowmeter as the master meter, after the field meter was flow calibrated by the portable proving system. Therefore, variations in flow rate and properties of hydrocarbon fluids for vortex meter were limited as vortex meter could only be tested for the flow rates and properties of the hydrocarbon fluids for which the field meter were being calibrated. Vortex meter proving and performance data for hydrocarbon liquids presented in this technical report are limited. While developing this report, there was no significant test data available in literature or in the public domain for vortex meters that characterized the performance of vortex meters with hydrocarbon liquid flows indicating the precision and uncertainty.

Members of the API Working Group were assigned to evaluate the performance characteristics of liquid vortex meters, document the response of vortex meters for hydrocarbon liquids, and to develop this Technical Report to examine the current use of liquid vortex meters. Therefore, individuals who use flowmeters can make an informed decision before selecting liquid vortex meters, to determine if the performance characteristics of the vortex meter can adequately meet the required measurement uncertainty when applied.

The Work Group appreciates the support of Coastal Flow and participating vendors that donated vortex meters for this study.

# Performance of Full-bore Vortex Meters for Measurement of Liquid Flows

## 1 Scope

This technical report provides:

- documentation of performance characteristics of full-bore liquid vortex meters for measuring liquid hydrocarbon flows of different API gravity under the field operating conditions and under a controlled environment in a laboratory test facility with water as the proving fluid.
- limited laboratory proving facility test results using water as the calibration fluid of several and 2 in. (50 mm) and 4 in. (100 mm) commercially available full-bore vortex meters that are typically installed for non-custody transfer liquid installations.
- typical performance of full-bore 4-in. (100-mm) liquid vortex meters for liquid hydrocarbon measurement and to provide guidance in selecting liquid vortex meters for custody transfer measurement.

## 2 References

- *API Manual of Petroleum Measurement Standards (MPMS) Chapter 4*
- *ASME Measurement of Fluid*
- *Flow in Pipes Using Vortex Flowmeters (MFC 6-2013), Appendix A*
- International Organization of Legal Metrology (OIML) D 25 Report, *Vortex meters used in measuring systems for fluids*, 2010

## 3 Terms, Definitions, and Abbreviations

For the purposes of this document, the following definitions apply.

### 3.1

#### **accuracy**

The extent to which the results of a calculation or the readings of an instrument approach the true value.

### 3.2

#### **bias**

Any influence on a result that produces an incorrect approximation of the true value of the variable being measured. Bias is the result of a predictable systematic error.

### 3.3

#### **calibration**

A set of operations which establish, under specified conditions, the relationship between the values indicated by a measuring device and the corresponding known values indicated when using a suitable measuring standard.

### 3.4

#### **compensation**

The adjustment of the measured value to reference conditions (e.g. pressure compensation).

### 3.5

#### **flowing density**

The density of the fluid at actual flowing temperature and pressure.