Manual of Petroleum Measurement Standards Chapter 22.3

Testing Protocol for Flare Gas Metering

ANSI/API MPMS CHAPTER 22.3
FIRST EDITION, AUGUST 2015

AMERICAN PETROLEUM INSTITUTE

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Users of this Standard should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

Page

1 Scope 1

2 Normative References. 1

3 Terms and Definitions 1

4 Field of Application 2

5 Parameter Variations Affecting Device Performance 3

6 Mandatory Tests. 3
6.1 Test Conditions 3
6.2 Test Installation 4
6.3 Test Results 8
6.4 Baseline Testing 8
6.5 Installation Effects Testing 8
6.6 Special Testing. 10
6.7 Testing Procedure 10

7 Test Facility Requirements 10
7.1 Audit Process. 10
7.2 Lab/Facility Qualification 11

8 Uncertainty Analysis and Calculation. 11
8.1 Test Facility Uncertainty 11
8.2 Device Uncertainty 11
8.3 How to Calculate Uncertainty. 11
8.4 Presentation of Test Report Uncertainty 11

9 Test Report 11
9.1 General 11
9.2 Test Facility Information 11
9.3 Test Meter Information 12
9.4 Description of the Full Test Matrix And Results 12
9.5 Sample Meter Test Reporting Form. 13

Annex A (informative) Samples for Summary and Detailed Data Reports 14

Bibliography 21

Figures
1 Test Program Piping Configuration. 7
2 Elbow in Plane Piping Layout with a USM in its Preferred Position 9
3 Elbow out of Plane Piping Layout with a USM in its Preferred Position. 9
X Picture of Meter Under Test 16
Y Baseline Meter Test Piping Arrangement (example) 18
Z Baseline Meter Test Piping (example). 18
AA Baseline Meter Test Result Summary (example) 19
AB Installation Effect Test Summary—2 Elbows Out of Plane (example). 20

Tables
X Reference Test Equipment Summary 17
Y Baseline Meter Test Summary (example) 19

Introduction

This document defines the testing and reporting protocols for a flare gas meter within a Flare Flow Meter System (FFMS). This protocol is designed to supply industry with a comparable description of the capabilities of flare gas meters for gaseous fluid flow measurement. The following are objectives of this Testing Protocol.

— Provide information about relative performance characteristics of the flare gas meter under a standardized testing protocol over an expected operating range with a standardized reporting format. (See 6.1 for determination of the expected operating range.)

— Facilitate both the understanding and the introduction of new technologies.

— Provide a standardized vehicle for manufacturers to validate the meter's performance.

— Quantify the uncertainty of these devices and define the operating and installation conditions for which the stated uncertainties apply.

To accomplish these objectives, in addition to the base testing requirements defined in this document, the end user should define any application specific requirements not covered by the base testing requirements such as the following.

— Expected operating range of the meter where this exceeds the base testing requirement operating range.

— Upstream flow disturbances not addressed by the base testing requirements.

— Criteria needed to comply with regulatory requirements.

When specifying additional testing requirements, the end user should insure that all parameters affecting the meter's performance are identified, but not limited to, items described in Section 6.

The facility selected to perform the tests has to be able to correlate the test fluid to the fluids to be measured at the expected process conditions.

Examples of flare gas meters covered in this standard include, but are not limited to differential pressure flow meters, optical meters, thermal flow meters, ultrasonic flare meters, vortex shedding meters.

If a meter has been tested under another API *MPMS* Chapter 22 testing protocol that covers the entire expected operating range for this application, testing the influence parameters listed in Section 5 and the ranges defined in 6.4, then additional testing is optional. Reporting and testing protocols for test facilities are included to ensure that the performance characteristics of each meter are compared with identical conditions as set forth in this standard.

Testing Protocol for Flare Gas Metering

1 Scope

The scope of the standard is to describe a testing protocol for flare gas meters. This includes a discussion of the testing to be performed, how the test data should be analyzed, and how an uncertainty is determined from the testing of the meter. The scope does not include the general guidelines to flare gas metering that are covered under *MPMS* Chapter 14.10.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API *Manual of Petroleum Measurement Standards (MPMS),* Chapter 14.3 Part 1, *Concentric, Square-Edged Orifice Meters—Part 1: General Equations and Uncertainty Guidelines*

ISO/IEC Guide 98-3:2008 [1], *Uncertainty of Measurement—Part 3: Guide to the Expression Uncertainty in Measurement (GUM: 1995)*

ISO/IEC 17025; 2005, *General requirements for the competence of testing and calibration laboratories*

3 Terms and Definitions

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

3.1
accuracy
The ability of a measurement instrument to indicate values closely approximating the true value of the quantity measured.

3.2
adiabatic expansion
Expansion of gas that occurs without loss or gain of heat.

3.3
calibration
The process or procedure of adjusting an instrument, such as a meter, so that its indication or registration is in satisfactorily close agreement with a reference standard.

3.4
D
The published inside pipe diameter.

3.5
dynamic performance
A general expression for the relationship between the volume or mass registered by a meter and the true value after a change in flow rate, flowing temperature or flowing pressure.

1 International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211, Geneva 20, Switzerland, www.iec.ch.

3.6
dynamic response
The time required for a meter to register 63.2 % of the difference between its old and new value after a change in flow rate, flowing temperature or flowing pressure.

3.7
flow disturbance
Any change in the swirl or asymmetry of the velocity profile capable of changing the output of the meter.

3.8
hysteresis
The difference between the indications of a measuring instrument when the same value of the quantity measured is reached by increasing or decreasing the quantity.

3.9
isentropic exponent
A thermodynamic state property that establishes the relationship between an expanding fluid's pressure and density as the fluid flows through the sensing element.

3.10
linearity
Meter linearity is expressed as the total range of deviation of the accuracy curve from a straight line between the minimum and maximum recommended flow rates.

3.11
rangeability
The capability of a meter or flow measuring device to operate between the minimum and maximum flow range within a specified uncertainty; expressed as the ratio of maximum flow to the minimum flow.

3.12
reference standard (metering)
The facility measuring instrument, which is traceable to national and/or international standards, intended to define, to represent physically, or to reproduce the unit of measurement of a quantity (or a multiple or submultiple of that unit), in order to transmit it to other measuring instruments.

3.13
repeatability
A measure of the agreement between the results of successive measurements of the same variable carried out by the same method, with the same instrument, at the same location, and within a short period of time.

3.14
sensing element
The part of the sensor (or detector) that is responsive to the magnitude of the measured quantity.

3.15
uncertainty
The amount and probability by which an observed or calculated value may depart from the true value.

4 Field of Application

This testing protocol is limited to sensing elements of meters that are used in the measurement of flare gas flow in the petroleum, energy, and petrochemical industries.

5 Parameter Variations Affecting Device Performance

As discussed in API *MPMS* Chapter 14.10 there are many parameters that may affect the performance of the device. The key parameters that will best define the performance of the Flare Flow Meter System (FFMS) metering component include but are not limited to the following:

— pressure;

— temperature;

— gas composition;

— environmental conditions;

— installation conditions such as upstream piping disturbances (influences will vary between different meter technologies);

— velocity;

— Reynolds Number;

— phase changes.

6 Mandatory Tests

6.1 Test Conditions

Written procedures should be developed by the testing facility and agreed by the party requesting the test prior to the start of any testing. The sequence of tests should be considered and any tests that can alter device performance should be completed last. All deviations from written procedures or standards shall be documented.

During the test, the environment should stay as stable as possible minimizing temperature, pressure, and barometric pressure excursions. For this reason the entire test should be conducted in one setting. Care should be taken to ensure that environmental/external conditions not being tested are held as consistent as possible to minimize their effect on the test results. The environmental/external conditions shall be recorded and reported. The average operating value and range of temperature, relative humidity, and atmospheric pressure during the test shall be measured and reported.

Significant temperature changes may influence the performance of flare flow meters through the change of critical geometric parameters and fluid properties. Meter manufacturers shall state corrections to be used in data processing. It is generally impractical to change the fluid temperature in a flow laboratory; consequently, the flowing fluid temperature should simply be recorded.

It is the responsibility of the manufacturer to specify the allowable range of the flare meter to be used with specific fluids, based on the thermodynamic properties of the fluids, mechanical and fluid dynamic constraints. In no case shall the velocities in these tests exceed the limits imposed by mechanical and fluid dynamic constraints.

If the flare meter is sensitive to compositional changes, then the manufacturer shall provide documentation detailing the sensitivity of their meter to changes in composition. In some cases additional testing may also be required to validate the sensitivity to fluid composition.

Air and other gases can be used provided the test fluid remains homogeneous and in a single phase during the test. The end-user's composition may vary so it is the end-user's responsibility to obtain correlating data from the manufacturer detailing how the meter will respond to the end user's application.

6.2 Test Installation

6.2.1 General

This section defines:

— the type of tests needed;

— the type of instruments to be tested;

— the range of environmental conditions;

— the range of process conditions;

— the fluid for testing the flare flow meter;

— the size of the process piping;

— process piping connections;

— upstream and downstream piping;

— the variables to be recorded;

— traceability and calibration records of laboratory measurement equipment.

6.2.2 Type of Tests

6.2.2.1 Baseline Testing

In order to identify the influence of certain parameters or changes to the operating conditions, baseline tests are necessary. The following testing is required to determine the flare flow measurement instrument's performance:

— reference accuracy,

— linearity,

— repeatability,

— hysteresis,

— rangeability.

For meters that are sensitive to other influence parameters such as pressure, temperature, or compositional changes, baseline testing shall also address these parameters.

6.2.2.2 Non-ideal Condition Testing

Non-ideal condition testing quantifies environmental effects and the dynamic performance of flare flow measurement instruments including:

— non-ideal piping configuration [one elbow in plane (EIP), two close-coupled elbows out of plane (EOP)].

Manufacturers shall also demonstrate the sensitivity of their meter to pressure, temperature and compositional changes and if necessary provide additional documentation and/or testing.

6.2.2.3 Special Testing

Installation specific testing as defined by the end user and/or manufacturer to quantify performance.

6.2.2.4 Other Testing

There are many factors which can affect the performance of a flare flow meter. It is not the intent of this standard to provide a testing protocol for these factors which include but are not limited to:

— mounting position;

— stability and drift;

— ambient temperature effects;

— dynamic response;

— mechanical vibration;

— electromagnetic interference (EMI)/radio frequency interference (RFI);

— electrostatic discharges;

— effect of compositional changes;

— power supply;

— effect of particulates and aerosols;

— phase changes/mixed phases.

Users are encouraged to consider these factors when evaluating various metering technologies.

6.2.3 Type of Instruments to be Tested

The types of instruments to be tested include but are not limited to the following:

— differential pressure flow meters;

— optical meters;

— thermal flow meters;

— ultrasonic flare meters;

— vortex shedding meters;

— other technologies (e.g. Coriolis meters).

6.2.4 Testing Fluid

Most test facilities use air as the testing fluid. Flare gas is usually composed of many gases with different densities and different viscosities. The pipe Reynolds Number is most often used to account for differences between a meter's performance in the testing fluid (usually air) and the flare gas. Pipe Reynolds Number characterizes the shape of a pipe's velocity profile and accounts for differences between the test fluid and the flare gas' density and viscosity. By matching the pipe Reynolds Number, velocity profiles found on the FFMS can be well modeled by the test facility. This can be especially important in lower velocities.

The velocity at the test facility to yield the equivalent test Reynolds Number for the application is given by the following equation:

$$V_{\text{TestFacility}} = \left(\frac{\mu_{\text{TestingFacility}}}{\mu_{\text{FFMS}}}\right)\left(\frac{\rho_{\text{FFMS}}}{\rho_{\text{TestingFacility}}}\right)\left(\frac{D_{\text{FFMS}}}{D_{\text{TestingFacility}}}\right)V_{\text{FMMS}}$$

where

V is the flowing velocity;

μ is the viscosity;

ρ is the flowing density;

D is the diameter.

In addition to correlating the pipe Reynolds Number, the expansion of the flare gas in the flow meter needs to be considered (especially at high velocities). Most manufacturers have a gas expansion factor equation. If a manufacturer does not have a gas expansion factor equation, the theoretical adiabatic expansion factor equation can be used. Gas expansion factor equations are often a function of the pressure drop across the meter, the operating static pressure, the gases' isentropic exponent, and the meter's blockage in the pipe. Differences in the gas expansion corrections are usually not accounted for during testing but are mathematically corrected for by applying the manufacturer's gas expansion factor equation and inputting the correct isentropic exponent into the manufacturer's gas expansion equation.

For the tests covered by this standard, gas velocities shall be from 0.03 m/s (0.1 ft/s) up to the maximum design velocity of the flare flow meter.

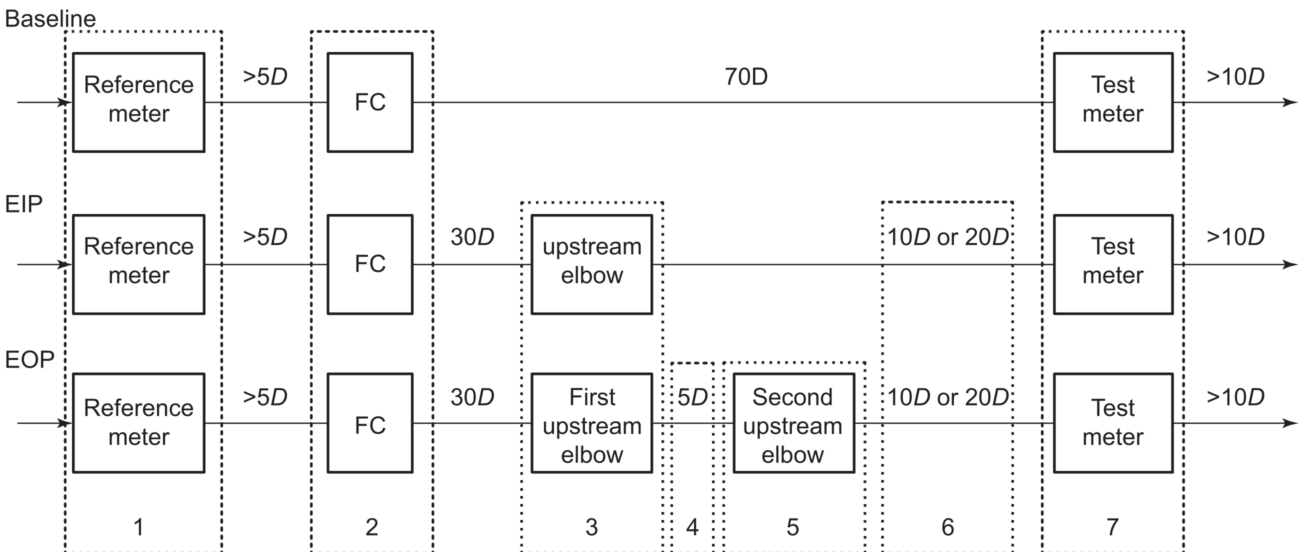
6.2.5 The Size of the Process Piping

If a manufacturer has test data and methodology that correlates a meter's performance from one pipe size to a different pipe size, the supporting test data and documentation should be carefully considered. Variables such as the meter's blockage, the pipe Reynolds Number, and the meter's inherent technology should also be carefully considered. The user is cautioned that upstream and downstream installation effects on some meter technologies do not correlate with increasing/decreasing pipe sizes.

6.2.6 Process Piping Connection

Abrupt changes of the inside meter tube surface (shoulders, offsets, ridges, welding seams, and the like) shall not exist in the meter tubes. The manufacturer shall state requirements for the meter tube.

Figure 1 provides is a generic diagram of the piping configurations for a meter under test.



Components:

1 Reference meter
2 Facility flow conditioner (FC)
3 Elbow for 1 EIP and 2 EOP tests
4 Separation straight run length between elbows
5 Elbow for 2 EOP tests
6 Variable test meter upstream lengths
7 Test meter

NOTE 1 Reference device may be upstream or downstream of the test meter. Applicable pipe lengths should be used in the case of a downstream reference to ensure accurate measurement and no effect on the test meter.

NOTE 2 For the mandatory tests, a perforated plate flow conditioner with at least 5*D* upstream and 30*D* downstream is required.

NOTE 3 The elbows are only inserted for the flow disturbance tests.

NOTE 4 The test meter upstream length is adjusted per the test program when elbow(s) are installed.

NOTE 5 The downstream straight length is at least 10*D* for all tests.

Figure 1—Test Program Piping Configuration

Dimensions of straight lengths of pipe upstream and downstream of the meter and location and dimensions of elbows, swirl generators, flow conditioners, valves, and other disturbances used for the test shall be measured and recorded. Pipe diameters (D) measured at different orientations immediately upstream and downstream of the meter being tested shall be measured and documented along with inside surface finish.

It is essential that the test facility notes the pressure rating for all the items being tested and ensures that the metering device and associated equipment are not overstressed (as a guideline, test pressure should not exceed 90 % of the design pressure of the meter).

Mounting configuration and connection type (NPT, flanged, etc) should be noted.

The orientation of the profile distortion device relative to the orientation of the meter shall be noted (i.e. 90° elbow is in plane with the single path Ultrasonic Meter (USM) orientation).

The orientation of the meter (horizontal or vertical) shall also be noted.

Piping schematic showing the number of pipe diameters (or distances) of the upstream and downstream disturbances of the test installation, the location of pressure taps, temperature devices, and other instruments used during the testing.

6.2.7 Traceability and Calibration Records of the Test Facility

Test facility measurement systems for mass, length, time, temperature, and pressure shall be traceable to National Institute of Standards and Technology (NIST) Primary Standards or an equivalent National or International Standard.

Record and document the traceability to a national standard (e.g. NIST).

The lab measurement system uncertainty shall be sufficient to support the test results.

6.3 Test Results

The parameter(s) defining the performance of the device (i.e. test results) shall be recorded during and after each test.

It is recognized that flare meters may not achieve their specified accuracy over the entire test range however from a user's perspective it is important to know the limitations and increased uncertainties over the full velocity range.

6.4 Baseline Testing

This standard requires Baseline Tests to establish a meter's performance under a fully-developed flow profile. Therefore, the meter should be tested under upstream and downstream piping conditions as set forth by the manufacturer. The primary purpose of baseline testing is to establish the data required to determine the uncertainties indicated in Section 8.

The purpose of the baseline test is to establish:

— range—minimum and maximum measurable;

— linearity;

— hysteresis;

— baseline for the non-ideal testing;

— proper operation of the test loop.

As noted in API *MPMS* Chapter 14.10, most flare headers are designed to operate at velocities less than 91 m/s (300 ft/s), with extremes up to 183 m/s (600 ft/s). For some meters the associated differential pressure may be excessively high at these stated velocities. Since most flare headers operate between 3.45 kPa-g (0.5 psig) and 310.3 kPa-g (45 psig) and between –100 °C (–148 °F) and 300 °C (572 °F), the manufacturer needs to test within this test range. If the end user has conditions that differ from those above, then additional testing may be required at the end user's specific operating conditions to prove that the meter will satisfy the required process ranges. The test report shall state the maximum velocities observed during the tests.

For any subsequent testing that is done after the initial baseline tests have been performed, it should be verified that nothing has changed in the test facility or the device being tested that would affect the test results.

6.5 Installation Effects Testing

Most flare meters will be significantly affected by installation conditions such as non-ideal upstream piping geometry. Therefore, the testing must be performed using the manufacturer's minimum base upstream configuration with one elbow in plane immediately upstream of the straight run. If the meter is orientation dependent, a subsequent test shall be conducted with one elbow out of plane with respect to the flow meter. The test report shall document the data from these tests.

The Mandatory Tests shall include:

— 10D with EIP;

— 10D with 2 EOP separated by 5D;

— 20D with EIP;

— 20D with 2 EOP separated by 5D.

The manufacturer shall perform the elbow tests with their meter in their recommended orientation. Figure 2 and Figure 3 depict the piping requirements for the EIP and EOP Tests.

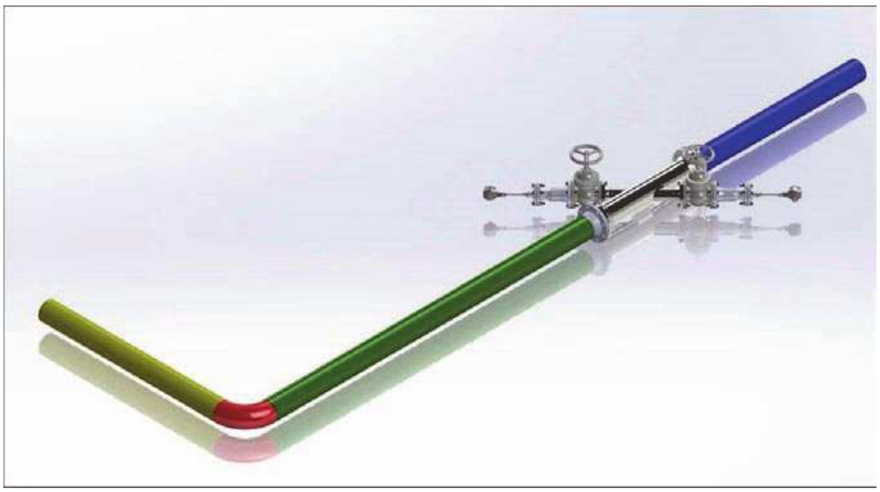


Figure 2—Elbow in Plane Piping Layout with a USM in its Preferred Position

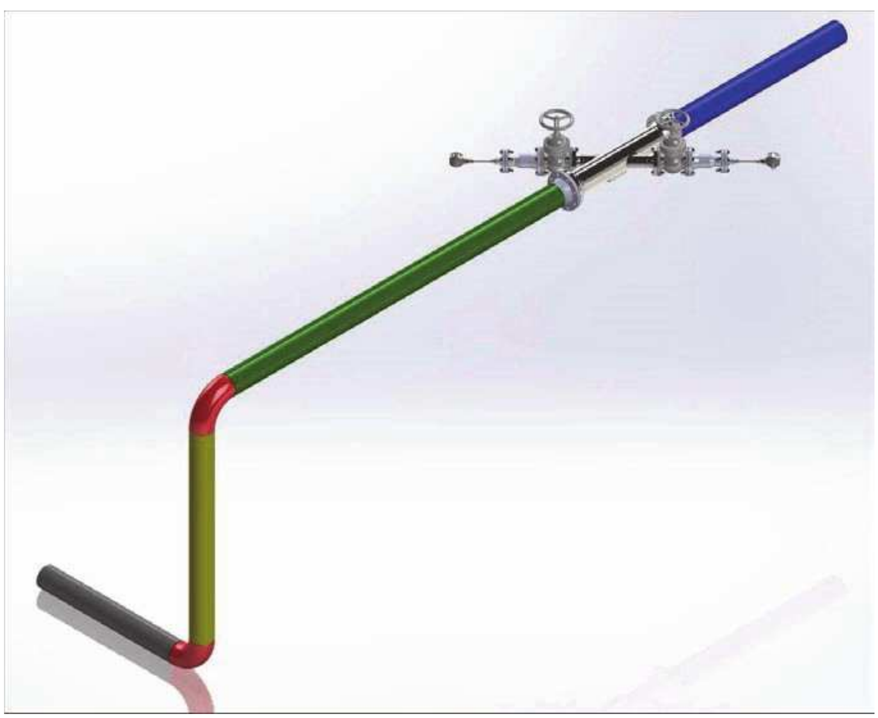


Figure 3—Elbow out of Plane Piping Layout with a USM in its Preferred Position

6.6 Special Testing

The end user should consider that there are many other factors that can influence and affect flare flow meters including the items listed in 6.2.2. In lieu of performing additional tests to address those items, the manufacturer may provide data to show how their meter is affected by these items.

The Special Tests may include the following:

— as per the manufacturers minimum upstream length with elbow in plane;

— as per the manufacturers minimum upstream length with 2 close coupled elbows out of plane;

— as per the end user's specific application requirements if it differs from the tests above.

6.7 Testing Procedure

The mandatory test procedure shall be as follows.

— The test points should cover the following velocities: 0.1, 0.5, 1, 2, 5, 10, 20, 50, 100 ft/s (0.03, 0.15, 0.30, 0.61, 1.5, 3.0, 6.1, 15, 30 m/s) then at 50 ft/s (15 m/s) increments up to the maximum velocity or capability of the meter.

— Adjust the flow rate until stable and obtain readings as follows:

  — 5 readings;

  — 1 reading = 1 data set = a minimum of 30 seconds of data with 1 data point recorded per second. Determine the standard deviation, average, and repeatability of the 5 readings.

— Test should be run as follows.

  1) Starting at the minimum or maximum point, run through the first three consecutive velocities gathering readings as described above.

  2) Drop back by one velocity point and perform a repeat (e.g. 0.1, 0.5, 1.0, repeat 0.5 if going up). The repeat point value should be within 5 % of the initial run at that velocity point.

  3) Run through the next three velocities followed by another repeat point (e.g. 2, 5, 10, repeat 5 if going up).

  4) Continue until all test velocities are covered.

— As noted previously, it is important that the tests are performed at a low pressure to mimic typical flare systems.

Additional testing, including ramping downward and testing at specific velocities of interest is discretionary.

7 Test Facility Requirements

7.1 Audit Process

In order to assure validity of tests performed following the testing protocols defined in this chapter, the laboratory or testing facility performing the tests shall provide evidence that the tests are performed in accordance with the standard. This evidence shall be provided at the request of any user of the facility.

Providing validity that the tests were performed in accordance with the test procedure is the responsibility of the user of the facility. The user of the facility can request an audit of the laboratory or the testing facility to ensure the validity of the tests.

7.2 Lab/Facility Qualification

The laboratory/facility measurements shall be traceable to NIST or other national standards. The facility shall be ISO/IEC 17025;2005, or most current revision, accredited and adhere to its audit measurement assurance and measurement uncertainty statement calculation requirements.

8 Uncertainty Analysis and Calculation

8.1 Test Facility Uncertainty

The test facility uncertainty shall be calculated according to the requirements of the latest revision of ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories.

8.2 Device Uncertainty

It is the manufacturer's responsibility to provide a statement of the device's uncertainty. The manufacturer shall make available the following to the user:

— the meter uncertainty statement;

— the statistical basis for the uncertainty statement.

It is the users responsibility to determine whether the device uncertainty statement includes field installation effects.

8.3 How to Calculate Uncertainty

Uncertainty shall be calculated according to the latest revision of ISO/IEC Guide 98-3:2008, *Uncertainty of Measurement—Part 3: Guide to the Expression Uncertainty in Measurement* (GUM:1995), or *MPMS* Chapter 14.3 Part 1.

8.4 Presentation of Test Report Uncertainty

Section 6 Mandatory Tests and Section 9 Test Reports specify how the tests are to be conducted and reported.

9 Test Report

9.1 General

The Test Report shall contain the following information.

9.2 Test Facility Information

The following information meets the minimal requirements for the Test Report covering the Test Facility information.

— Name, location, and specific the test facility used for the test.

— Date(s) of the test.

— Fluid used.

— Manufacturer, model number, and uncertainty of transmitters used to measure pressure, differential pressure, density and temperature during the test. Upon request, copies of relevant calibration certificates shall be included for all the transmitters.

— Environmental conditions including temperature, barometric pressure, and relative humidity at the beginning of each series of data point.

— Uncertainty of reference flow rate.

9.3 Test Meter Information

The following information meets the minimal requirements for the Test Report covering the MUT.

— Name of the manufacturer.

— Meter type/technology.

— Serial numbers, model number, and any other identifying information including revision or release of both sensors and electronics.

— Nominal pipe size at the measurement point.

— Piping schedule with pressure rating.

— Meter geometry and critical dimensions:

  — outline dimensional drawing,

  — insertion depth, location and angles (if applicable),

  — internal diameter,

  — number of measurement points (e.g. multi-path ultrasonic meters).

— Manufacturer’s discharge coefficient (C_d) and/or calibration certificate, if applicable.

— All equations required to predict the flow rate for the test meter should be clearly stated in the test report, especially those that are specifically used for that type of meter design. Equations should include the expansibility equation (including the limitations for the ratio of differential pressure to static pressure DP/P1), the discharge coefficient equations and the flow rate equation, when applicable.

— Manufacturer’s required point of pressure and temperature measurement.

9.4 Description of the Full Test Matrix And Results

The following information meets the minimal requirements for the Test Report covering the full test matrix and results.

— Clear indication of test type (e.g. “Baseline”, “Non-Ideal”, or “Special Test”).

— A drawing of the test installation noting the following:

  — meter orientation (i.e. horizontal or vertical, in plane, out of plane);

  — upstream and downstream piping distances including disturbances;

  — location of sensing devices.

- Test results summary including but not limited to:
  - meter linearity over test range for each type of test;
  - hysteresis over the test range for each type of test;
  - Meter repeatability at each flow rate including all raw data for each type of test;
  - For flow disturbance tests, variance from baseline tests for each data point (flow rate);
  - Environmental conditions; ambient temp, humidity, barometric pressure, etc.;
  - Test fluid properties;
  - Standard conditions basis.
- Detailed table of results for each reading, including estimates of uncertainty in measurement parameters.
- The detailed results shall include:
  - flow meter reported velocity, flow rate at standard conditions, pressure, temperature;
  - calibration facility reported velocity, flow rate at standard conditions, pressure, temperature;
  - any technology specific parameters such as DP, and DP/P1 for differential producing devices.

9.5 Sample Meter Test Reporting Form

Annex A shows samples for the summary and detailed data reports.

Annex A
(informative)

Samples for Summary and Detailed Data Reports [2]

[2] The examples in this Annex are merely examples for illustration purposes only. [Each company should develop its own approach.] They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

Report #: xxxxx

FLARE GAS METER PERFORMANCE TEST REPORT

API *MPMS* CHAPTER 22.3 TESTING PROTOCOL

[MANUFACTURER'S NAME] 10 INCH ULTRASONIC METER

Prepared by:

[report author]

[testing facility name]

[testing facility address]

Prepared for:

[Client company name]

[Client company address]

[Report date]

INTRODUCTION

[*A short introduction such as the following*.]

This report presents the results of tests of a 10 inch [insert manufacturer model] number according to the test protocol defined in API 22.3 *Testing Protocol for Flare Gas Metering*. The testing program was carried out at [insert test facility name, location etc.] [insert date] using [insert fluid].

[*Insert brief description of theory of operation of meter under test*.]

TECHNICAL APPROACH

Test Meter

Manufacturer:

Type:

Model:

Size:

Connections:

Serial Number:

Output:

Previous Calibration:

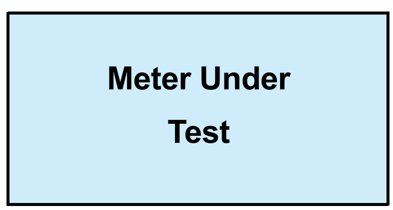


Figure X—Picture of Meter Under Test

Test Facility

Name:

Location:

System Uncertainty:

Test Equipment

The equipment utilized for this test program is summarized in the following table.

Table X—Reference Test Equipment Summary

	Model	Range	Serial #	Uncertainty	Prior Calibration	Comments
Reference Meter #1						
Reference Meter #2						
Pressure Transmitter #1						
Pressure Transmitter #2						
Temperature Transmitter #1						
Temperature Transmitter #2						
Analyzer						
Notes: 1)						

Test Condition Summary

Test Fluid:

Test Pressures:

Test Temperatures:

Reynolds Number Range:

Velocity Range:

Flow Rate Range:

Baseline Meter Performance Results

[*Describe baseline test results including tables and graphs. Present meter under test errors relative to reference meter. Detail if meter factors were adjusted after baseline test. Include schematics and pictures to describe piping arrangement.*]

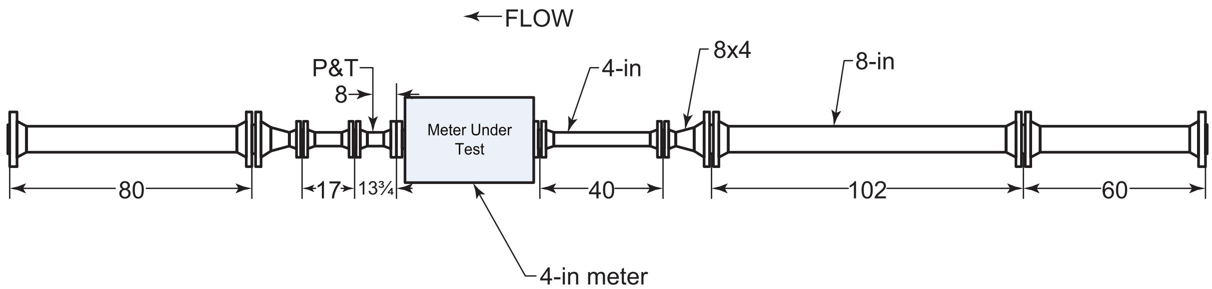


Figure Y—Baseline Meter Test Piping Arrangement (example)

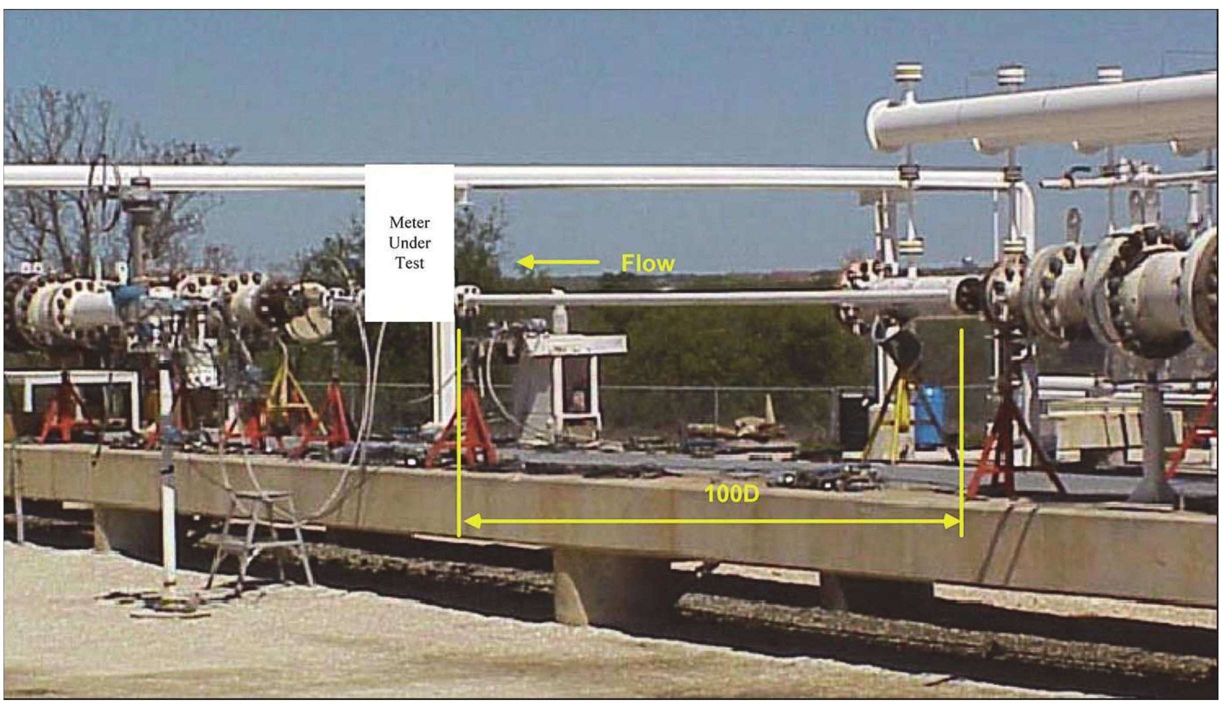


Figure Z—Baseline Meter Test Piping (example)

Table Y—Baseline Meter Test Summary (example)

Data Point	Target Velocity	Reference Meter Mass Flow Rate	Meter Under Test								
			Temp.	Pres.	Reynolds Number	Flowing Density	Flow Rate	Computed Velocity	Measured Velocity	Error	Data File
	fps	lb/h	°F	psia		lb/ft^3	ACFH	fps	fps	% rdg	
1	0.1	0.9	79.8	11.95	461	0.05980	14.4	0.119	0.113	-5.04	06X-06
2	0.5	3.7	80.4	11.95	2007	0.05974	62.7	0.518	0.501	-3.28	06X-07
3	1	8.6	79.8	11.95	4596	0.05980	143.5	1.186	1.166	-1.69	06X-08
4	0.5	3.7	80.4	11.95	2007	0.05974	62.7	0.518	0.501	-3.28	06X-09
5	2	17.0	80.4	11.95	9122	0.05974	284.8	2.354	2.363	0.38	06X-10
6	5	36.5	79.9	11.95	19538	0.05979	610.1	5.042	5.07	0.56	06X-11
7	10	73.3	80.1	11.95	39266	0.05977	1226.1	10.133	10.232	0.98	06X-12
8	5	36.5	79.9	11.95	19546	0.05979	610.3	5.044	5.072	0.56	06X-13
9	20	141.7	81	11.95	76037	0.05967	2374.3	19.622	19.775	0.78	06X-14
10	50	358.2	81.3	11.95	192350	0.05964	6006.3	49.638	50.042	0.81	06X-15
11	100	756.6	83.4	11.92	408901	0.05926	12768.2	105.521	106.394	0.83	06X-16
12	50	358.1	81.3	11.94	192436	0.05959	6009.0	49.66	50.061	0.81	06X-17
13	150	1101.2	83.3	11.89	596539	0.05912	18627.4	153.943	154.796	0.55	06X-18
14	200	1409.6	83.5	11.88	764527	0.05905	23872.9	197.294	198.139	0.43	06X-19
15	250	1784.7	84.7	11.81	975850	0.05857	30471.7	251.828	252.875	0.42	06X-20
16	200	1410.2	83.5	11.88	764821	0.05905	23882.1	197.37	198.215	0.43	06X-21
17	300	2127.6	85.7	11.77	1169413	0.05826	36515.8	301.779	302.767	0.33	06X-22

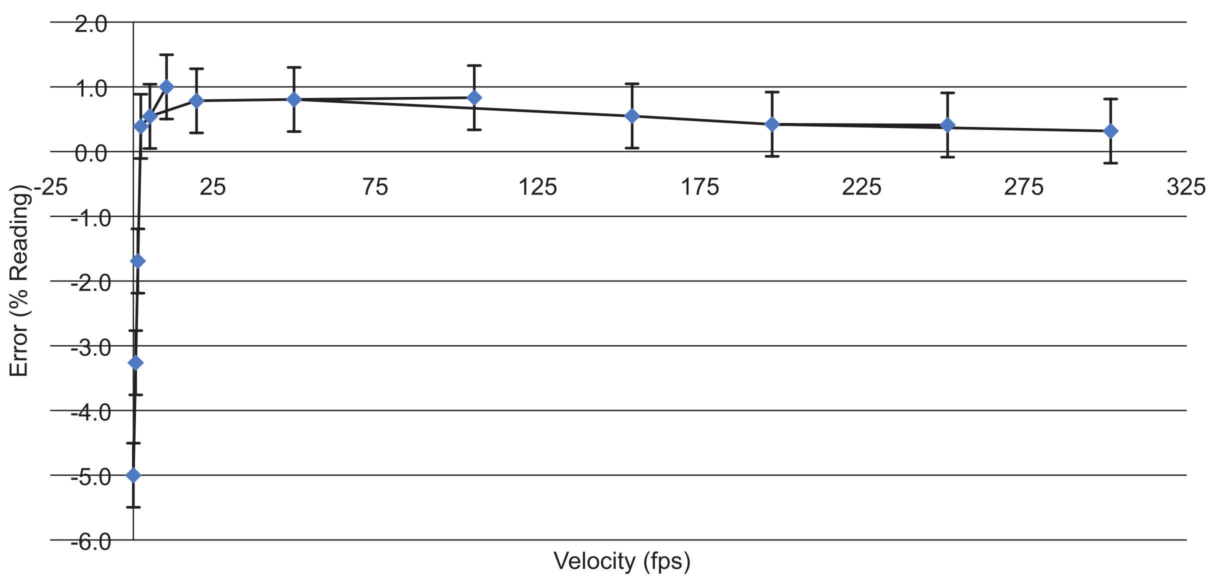


Figure AA—Baseline Meter Test Result Summary (example)

Installation Effects Tests

[*Describe how the tests were performed.*]

[*Describe piping for flow disturbance tests (include schematics and pictures as per examples above).*]

[*Describe flow disturbance test results including tables and graphs as above. Present meter under test errors relative to baseline tests (i.e. change from baseline).*]

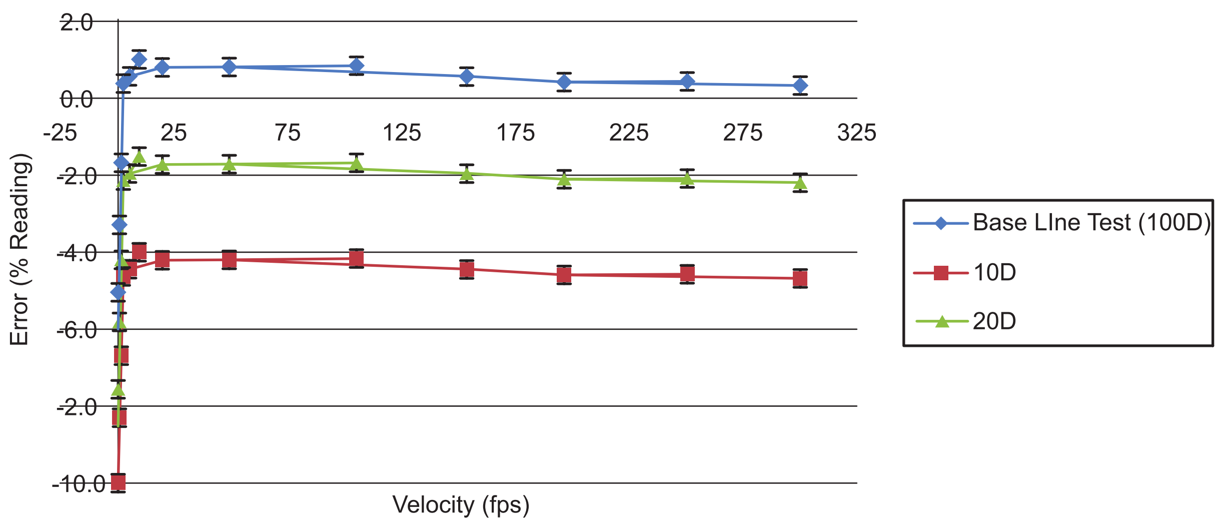


Figure AB—Installation Effect Test Summary—2 Elbows Out of Plane (example)

Bibliography

[1] API *Manual of Petroleum Measurement Standards (MPMS)*, Chapter 14.10, *Measurement of Flow to Flares*

[2] API *Manual of Petroleum Measurement Standards (MPMS)*, Chapter 21.1, *Electronic Gas Measurement*

AMERICAN PETROLEUM INSTITUTE

1220 L Street, NW
Washington, DC 20005-4070
USA

202-682-8000

Additional copies are available online at www.api.org/pubs

Phone Orders:	1-800-854-7179	(Toll-free in the U.S. and Canada)
	303-397-7956	(Local and International)
Fax Orders:	303-397-2740	

Information about API publications, programs and services is available on the web at www.api.org.

Product No. H220301