

Manual of Petroleum Measurement Standards Chapter 14.10

**Natural Gas Fluids Measurement—Measurement of Flow
to Flares**

SECOND EDITION, DECEMBER 2021



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. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

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 ensure 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 used. 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 *MPMS* 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.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001-5571.

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.

The verbal forms used to express the provisions in this document are as follows.

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

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

May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, “can” denotes a statement of possibility or capability.

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, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001. 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, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

Currently in preview, click buy full version

Contents

	Page
1 Scope.....	1
1.1 General.....	1
1.2 Field of Application.....	1
2 Normative References.....	1
3 Terms and Definitions.....	2
4 Application Considerations for Meters in Flare Systems.....	3
4.1 Overview.....	3
4.2 Flare Metering Technologies.....	4
4.3 General Considerations for Design and Selection of an FFMS.....	6
4.4 Location of Flare Meters.....	6
4.5 Application-specific Factors Affecting Flow Meter Performance.....	7
4.6 Meter Sizing.....	8
4.7 Measurement Uncertainty.....	9
4.8 Flow Meter Selection.....	9
4.9 Specific Meter Considerations.....	12
4.10 Secondary Instrumentation.....	17
4.11 Design Considerations.....	17
4.12 Record-keeping.....	18
5 Factory Calibrations/Verifications.....	18
5.1 Flow Meter.....	18
5.2 Pressure And Temperature Instruments.....	18
6 Commissioning and Startup.....	19
6.1 General.....	19
6.2 Flare Meter Commissioning.....	19
7 Periodic Verification.....	21
7.1 General.....	21
7.2 Periodic Verification Method 1—Flow Meter.....	21
7.3 Periodic Verification Method 2—Secondary Devices.....	22
8 Reevaluation of Existing FFMS.....	22
8.1 General.....	22
8.2 Reevaluation Procedure.....	22
9 Performance Test Protocol Scope.....	23
10 Uncertainty and Propagation of Error.....	23
10.1 Objective.....	23
10.2 Uncertainty Analysis Procedure.....	23
10.3 Simplified Uncertainty Analysis Procedure.....	24
10.4 Uncertainty Estimate for Flare Composition.....	26
10.5 Meter-specific Examples.....	29
11 Documentation.....	30
11.1 Procedural Documentation.....	30
11.2 Scaling Documentation.....	30

Contents

	Page
11.3 Other Documentation.....	30
11.4 Audit Trail Documentation and Retention	30
Annex A (informative) Process Stream Data Sheet.....	32
Annex B (informative) Flare Meter Calculations	33
Annex C (informative) Compressibility Effects on Flare Gas Measurement Uncertainty	38
Annex D (informative) General Flare Design Considerations.....	39
Annex E (informative) Guidance on Management of Change Process FFMS Systems	48
Annex F (informative) Velocity Profile and Velocity Integration for Flare Gas Measurement.....	50
Annex G (informative) Uncertainty Calculation Examples.....	56
Bibliography.....	63

Figures

1 Flare Flow Measurement System (FFMS) Graphical Representation of an FFMS and its Relation to Other Devices.....	4
2 Vortex Shedding Principle.....	6
3 Thermal Flow Meter Detail.....	15
4 In-line and Insertion Vortex Shedding Meters.....	16
5 FFMS Commissioning and Verification.....	20
6 Measurement Error Caused by Gas Composition Analysis Delay.....	28
A.1 Example Process Stream Data Sheet	32
D.1 Single Point Flare Burner.....	39
D.2 Purge Reduction Seals	40
D.3 Plant or Operating Unit Knock-out Drum	40
D.4 Local Knock-out Drum	40
D.5 Local Water Seal.....	40
D.6 Local Water Seal with Local Knock-out Drum.....	41
D.7 Air-assisted Flare.....	41
D.8 Enclosed Ground Flare.....	41
D.9 Flare Gas Recovery Unit	41
D.10 Waste Gas Riser.....	42
D.11 Staged Multi-burners	42
D.12 Large Gas Injection Point.....	42
D.13 Assent Gas Injection Point.....	42
D.14 FFMS in a Horizontal Section with No Additional Equipment	43
D.15 FFMS with an Optional Connection and an LWS.....	44
D.16 FFMS with an LKO	45
D.17 FFMS Following a PKO	46
D.18 FFMS in a Staged Multi-burner Flare System	46
D.19 Typical Staging Curve	46
F.1 Annulus Area vs Distance from the Center of the Pipe.....	51

Contents

	Page
F.2 Point Velocity vs Area Weighted Velocity.....	52
F.3 Predicted Velocity Contours through the Downstream of the Single Bend: a) Flow through the Bend (Insert—Predicted Vortices), b) Development after the Bend	53
F.4 Comparison of Axial Velocity on the Horizontal Axis with NIST Data at Various Axial Distances from the Bend	54

Tables

1 Guidance on Sensitivity to Entrained Mist, Liquid, Particulates, and Fouling	11
2 Guidance on Installation effects and Secondary Instrument Requirements for Pressure, Temperature, and Composition.....	11
3 Upstream or Downstream Location of Pressure Devices Relative to the Flare Flow Meter	17
4 Example Table of Combined Uncertainties	26
5 Errors Related to Use of Fixed Composition for Different Meter and Calculation Types (Absolute Value of Error).....	29
6 Procedures and Responsibilities for Documentation	30
B.1 Meter Equation Matrix.....	33
F.1 Velocity/Pipe Bulk Average Velocity.....	53
F.2 Table of Meter Errors Meter Using the Fully Developed Profile vs 11.2D Profile.....	54
F.3 Table of Meter Errors Meter Using the Fully Developed Profile vs 2.7D Profile	54
G.1 Linear Volume Meter Measuring Standard Volumetric Flowrate.....	57
G.2 Random Uncertainty—Linear Volume Meter Measuring Standard Volumetric Flowrate	57
G.3 Systematic Uncertainty—Linear Volume Meter Measuring Standard Volumetric Flowrate	58
G.4 Averaging Pitot Tube Measuring Standard Volumetric Flowrate.....	60
G.5 Random Uncertainty—Averaging Pitot Tube Measuring Standard Volumetric Flowrate	60
G.6 Systematic Uncertainty—Averaging Pitot Tube Measuring Standard Volumetric Flowrate	61
G.7 Thermal Flow Meter Measuring Mass Flowrate.....	61
G.8 Random Uncertainty—Thermal Flow Meter Measuring Mass Flowrate	62
G.9 Systematic Uncertainty—Thermal Flow Meter Measuring Mass Flowrate	62

Currently in preview, click buy full version

Introduction

Measurement of flow to flares is important from accounting, mass balance, energy conservation, emissions reduction, and regulatory perspectives. However, measurement of flow to flares remains distinctly different from traditional fiscal measurement practices. Flares are safety-relief systems, which typically receive highly unpredictable rates of flow and varying compositions; for safety reasons, they do not often lend themselves to being taken out of service to accommodate measurement concerns, even for short periods. Therefore, some of the traditional paradigms applicable to fiscal measurement systems, such as reasonably predictable flow rates and composition, the use of in-line provision, capability to readily remove meters from the piping system, the use of by-pass connections, and the use of master meters, for example, have to be abandoned altogether or highly modified in flare measurement applications. Use of measurement systems with diagnostic and verification capability might be one solution to ensure the performance.

Currently in preview, click buy full version

Natural Gas Fluids Measurement—Measurement of Flow to Flares

1 Scope

1.1 General

The standard addresses measurement of flow to flares, and includes:

- application considerations;
- selection criteria and other considerations for flare meters and related instrumentation;
- installation considerations;
- limitations of flare measurement technologies;
- calibration;
- operation;
- uncertainty and propagation of error;
- calculations.

The scope of this standard does not include analytical instrumentation.

1.2 Field of Application

For safety and other considerations, it is highly undesirable to directly flare multiphase mixtures of liquids and gases. Therefore, this standard is primarily concerned with flare flow measurement in the gas or vapor phase. However, considering that fouling substances such as liquid droplets and/or mist or other contaminants may be present even in well-designed flare systems, this standard provides appropriate cautionary detail as to the effects of such contaminants that may impact flare flow measurements.

Most flare header applications are designed to operate during non-upset conditions at near-atmospheric pressure and ambient temperature, where compressibility of the mixture is near unity. Extreme conditions have been noted to be between 97.925 kPa-a (14.196 psia) and 414 kPa-a (60 psia), and between $-150\text{ }^{\circ}\text{C}$ and $300\text{ }^{\circ}\text{C}$ ($-238\text{ }^{\circ}\text{F}$ and $572\text{ }^{\circ}\text{F}$). Flare gas compositions are highly variable and can range from average molecular weights approaching that of hydrogen to that of iso-pentanes and heavier. The uncertainty in flare gas density associated with varying pressure, temperature, and composition is discussed in more detail in 10.4.

Most flare headers are designed to operate at maximum velocities of 91 m/s (300 ft/s), with extremes up to 183 m/s (600 ft/s). This standard does not exclude pressures, temperatures, and velocity ranges different than those suggested above, as long as all applicable requirements are met.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API Manual of Petroleum Measurement Standards (MPMS) Chapter 21.1, Flow Measurement Using Electronic Metering Systems—Electronic Gas Measurement