

This is a preview of "ISO/TR 12748:2015". [Click here to purchase the full version from the ANSI store.](#)

First edition
2015-10-15

Natural Gas — Wet gas flow measurement in natural gas operations

*Gaz naturel — Mesurage du débit de gaz humide dans les opérations
de gaz naturel*



Reference number
ISO/TR 12748:2015(E)

© ISO 2015

This is a preview of "ISO/TR 12748:2015". [Click here to purchase the full version from the ANSI store.](#)



COPYRIGHT PROTECTED DOCUMENT

© ISO 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

This is a preview of "ISO/TR 12748:2015". [Click here to purchase the full version from the ANSI store.](#)

Contents

	Page
Foreword	vi
Introduction	vii
1 Scope	1
2 Terms and Definitions	1
3 Symbols	10
4 Objectives of wet gas flow measurement	13
4.1 Common production scenarios.....	14
4.2 Production allocation.....	15
4.3 Flow assurance aspects.....	16
4.4 WGFM considerations.....	16
4.5 Reliability in remote WGFM installations.....	16
5 Flow regimes	17
5.1 Horizontal wet gas flow regimes.....	17
5.1.1 Stratified flow.....	18
5.1.2 Slug flow.....	18
5.1.3 Annular mist flow.....	18
5.2 Vertical up wet gas flow regimes.....	18
5.2.1 Churn flow.....	18
5.2.2 Annular mist flow.....	19
5.3 Vertical down wet gas flow regimes.....	19
5.4 Inclined flow.....	19
5.5 Examples of wet gas flow regimes.....	19
5.6 Flow regime maps.....	20
5.7 Different wet gas flow parameters.....	21
5.8 Water in wet gas flow.....	21
6 Wet gas flow metering principles	22
6.1 General.....	22
6.2 In-Line wet gas flow meters.....	23
6.2.1 Single-phase gas flow meter with correction factor.....	23
6.2.2 Two-phase wet gas flow meter.....	24
6.2.3 Multiphase wet gas flow meter.....	24
6.3 Single-phase gas differential pressure meters with wet gas flow.....	24
6.3.1 DP Meter design influence on wet gas over-reading.....	25
6.3.2 Lockhart-Martinelli parameter influence on DP meter wet gas flow over-reading.....	25
6.3.3 Gas to liquid density ratio influence on DP meter wet gas flow over-reading.....	25
6.3.4 Gas densimetric Froude number influence on DP meter wet gas flow over-reading.....	26
6.3.5 DP meter orientation influence on DP meter wet gas flow over-reading.....	26
6.3.6 Influence of β on DP meter wet gas flow over-reading.....	28
6.3.7 Fluid property influence on DP meter wet gas flow over-reading.....	28
6.3.8 Meter size/diameter influence on DP meter wet gas flow over-reading.....	28
6.3.9 Applying DP meter wet gas flow correlations.....	28
6.4 General discussion on DP meter wet gas correlations.....	29
6.4.1 Wet gas flow performance characterization vs. published wet gas correlations.....	29
6.4.2 Horizontally-installed orifice plate meter.....	29
6.4.3 Horizontally-installed Venturi meter.....	31
6.4.4 Horizontally-installed cone meter.....	32
6.5 Generic two-phase wet gas meter designs.....	33
6.5.1 Multiple single-phase meters in series.....	33
6.5.2 Differential pressure meter classical DP/permanent pressure loss wet gas meters.....	35

6.5.3	Fast response sensor system.....	36
6.6	Multiphase wet gas flow meters.....	37
6.6.1	Trace water metering with multiphase wet gas flow meters.....	38
6.6.2	Multiphase wet gas flow meter subsystems.....	38
6.6.3	Phase fraction device choices.....	39
6.6.4	Gas volume fraction vs. gas void fraction measurement.....	41
6.6.5	Semi-empirical multiphase flow calculation — Slip model.....	41
6.6.6	PVT (pressure volume temperature) models.....	42
6.6.7	Multiphase wet gas flow meter required fluid property inputs.....	42
6.6.8	Multiphase wet gas flow meter phase fraction measurement.....	42
6.6.9	Measurement of water salinity.....	43
6.6.10	Multiphase wet gas flow meter redundant subsystems and diagnostics.....	43
6.6.11	Selection of multiphase wet gas flow meter technologies.....	44
6.7	Wet gas flow meter performance testing.....	44
6.8	Virtual metering system (VMS).....	45
7	DP Meter Wet Gas Correlation Practical Issues.....	45
7.1	DP meter wet gas flow installation issues.....	46
7.1.1	Liquid flow rate estimation techniques.....	46
7.1.2	Monitoring wet gas liquid loading with a DP meter downstream port.....	47
8	Design and Installation Considerations.....	49
8.1	Design considerations.....	49
8.1.1	Meter orientation and fluid flow.....	49
8.1.2	Meter location relative to other piping components.....	50
8.1.3	Use of two-phase flow rate and composition maps.....	50
8.1.4	Fluid sampling.....	52
8.1.5	Redundancy and external environmental considerations.....	52
8.1.6	Security.....	53
8.1.7	Cost and project schedule implications.....	54
8.2	Performance specifications.....	54
8.3	Wet gas flow measurement uncertainty.....	55
8.3.1	Uncertainty evaluation methodologies.....	55
8.3.2	Additional factors affecting wet gas flow measurement uncertainty.....	55
8.3.3	Expressing uncertainty of wet gas flow rates.....	56
9	Testing, Verification and Calibration.....	56
9.1	Meter orientation.....	56
9.2	Comments on flow regimes and mixers.....	57
9.3	Installation requirements.....	57
9.4	Wet gas flow characterization tests — Single-phase DP meter baselines.....	57
9.5	Wet gas flow facility operational considerations.....	58
9.5.1	Test facility operational issues — Achieving thermodynamic equilibrium.....	58
9.5.2	Test facility operational issues — Phase flow rate stability.....	60
9.5.3	Test facility operational issues — Witnessing of tests.....	61
9.6	Meter testing in a wet gas flow facility.....	62
10	Operational and Field Verification Issues.....	65
10.1	Laboratory reference vs. field hydrocarbon flow composition estimates.....	66
10.2	Laboratory reference vs. field calibration of phase fractions.....	66
10.3	Comparisons of multiphase wet gas flow meter and single-phase meter requirements.....	66
10.3.1	The challenge of supplying multiphase wet gas flow fluid properties.....	66
10.3.2	Confidential slip models.....	67
10.4	The importance of correct fluid property predictions.....	67
10.4.1	The importance of gas properties when metering small liquid flow rates.....	70
10.4.2	Preparation for fluid property variations during meter service.....	71
10.4.3	Fluid property sensitivity investigation.....	71
10.5	The benefit of an initial wet gas flow facility test.....	73
10.6	Line size limitations for some multiphase meters.....	73
10.7	<i>In situ</i> wet gas flow meter verification.....	73

This is a preview of "ISO/TR 12748:2015". [Click here to purchase the full version from the ANSI store.](#)

	10.7.1	Reconciliation factors and meter output confidence	74
10.8		Operation and maintenance	74
	10.8.1	System redundancy and diagnostics	74
	10.8.2	Operating WGFM diagnostics	75
10.9		Miscellaneous operational issues	76
	10.9.1	Wet gas flow and DP transmitters	76
	10.9.2	Software and fluid property update procedures	77
	10.9.3	Long term trending comparisons with test facility/factory characterization	77
11		Common Field Issues	77
	11.1	Inefficient separator systems	77
	11.2	Separator systems — An adverse environment for single-phase meters	78
	11.2.1	Separator Outlet deployment	79
	11.2.2	Gas Measurement at the separator outlet	79
	11.2.3	Liquid Turbine Meter	80
	11.2.4	Practical limitations of wet gas flow metering with separator technology	80
	11.3	Wet gas flow meter practical problems	81
	11.3.1	Considerations for wet gas flow metering	81
	11.3.2	The adverse effects of contamination, hydrates, scale, and salts	82
	11.3.3	Theoretical, laboratory and actual wet gas flow conditions	84
	11.3.4	Undisclosed WGFM calculation procedures	84
	11.3.5	Differential pressure measurement and wet gas flows	85
	11.3.6	Problems due to lack of long time operating experience of WGFM's	86
		Annex A (informative) WGFM design checklist	87
		Annex B (informative) Wet gas parameters equations	89
		Bibliography	90

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#).

The committee responsible for this document is ISO/TC 193, *Natural Gas*, Subcommittee SC 3, *Upstream Area*.

This is a preview of "ISO/TR 12748:2015". [Click here to purchase the full version from the ANSI store.](#)

Introduction

Oil and gas companies started developing Wet Gas Flow Meters (WGFMs) and Multiphase Flow Meters (MPFMs) through extensive R&D activities in the late 1980s. During this period, WGFMs and MPFMs were typically perceived as two distinct technologies for different applications: MPFMs were designed for liquid continuous flow conditions and WGFMs were designed for gas continuous flow conditions. In recent years, however, the operating range of these two technologies has increasingly overlapped, blurring the distinction between a WGFm and MPFM. As wet gas flow is presently considered a subset of multiphase flow, a WGFm is an MPFM that specializes in gas-dominant multiphase flow conditions. In this Technical Report, such technologies will be referred to as WGFMs.

There are many factors that contributed in the decision to replace a separator with a WGFm, with each application warranting careful consideration. A well-designed and maintained separator working within an appropriate flow condition range should produce accurate flow measurements. A primary concern for oil and gas companies was to reduce costs by replacing complex and bulky test separators, as well as to further simplify the upstream infrastructure, in particular for offshore and subsea projects. WGFMs typically require lower capital¹⁾ and operational²⁾ expenditures than fully equipped test separators. More savings in CapEx may be achieved by omitting dedicated test lines in satellite developments. In addition, there is a significant benefit for offshore developments, in terms of weight and space conservation, by using the much smaller footprint of WGFMs.

Due to various operational problems, a conventional test separator does not continuously provide accurate and reliable well test data, giving only relevant information when the well is switched to the test separator. With the use of WGFMs testing well production more frequently or even continuously becomes possible. WGFm developments and extensive testing over the last two decades have resulted in WGFm technology that is a viable alternative to a test separator. Modern WGFMs now offer continuous well monitoring (per installation on individual wells).

WGFm technology is an attractive option for multiphase wet gas flow measurement. Over the last two decades, some WGFMs have been developed from prototypes into very mature, robust, advanced, and field-proven measurement devices, increasing their application scope. Although originally intended for use mainly in reservoir and well production allocations, WGFMs have evolved into a technology that spans even fiscal product allocation. In the latter case, the output of a WGFm is used to determine money transactions between operating companies or between an operating company and a host government.

This Technical Report focuses on the measurement of wet gas flow, i.e. terminology, models, and principles, and the design, implementation, testing, and operation of WGFMs.

1) Capital expenditure (CapEx) or costs for purchasing and installing a WGFm/MPFM includes all hardware to operate the WGFm (data transmission, verification facilities, sampling arrangements, etc.)

2) Operating expenditure (OpEx) or costs to operate a WGFm/MPFM (maintenance, verification processes, sampling for fluid properties, etc.)