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Measurement of multiphase fluid flow

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Foreword

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 2, *Measurement of petroleum and related products*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The need for multiphase flow measurement in the oil and gas production industry has been evident for many years. Multiphase meters have been developed since the early eighties by research organizations, meter manufacturers, oil and gas production companies and others: different technologies and various combinations of technologies have been employed. Some technologies have been abandoned, whereas other meters have become commercially available: the number of applications and users is increasing.

The first Norwegian Society for Oil and Gas Measurement (NFOGM) handbook of multiphase metering (hereafter simply called the Handbook) was published in 1995 (see Reference [16]). Since then, multiphase flow measurement has matured. New applications of multiphase flow meters (MPFMs) have emerged, from simply being a replacement for the conventional test separator shared by a number of wells, towards more compact and low-cost meters with application on a one-per-well basis and installations on shore, topside and subsea.

Since multiphase flow metering technologies and applications had developed significantly since 1995, NFOGM updated the Handbook in 2003-5 to reflect these improvements and to make it the main guide for state-of-the-art multiphase flow measurement. That work was financed by NFOGM and The Norwegian Society of Chartered Technical and Scientific Professionals (Tekna).

Following calls from industry to produce an ISO document, NFOGM very generously allowed ISO to use the Handbook as the basis for this document.

This document is intended to serve as guidance for users, designers and manufacturers of multiphase metering systems.

The document can also serve as an introduction to newcomers in the field of multiphase flow measurement, with definition of terms and a description of multiphase flow in closed conduits being included.

Even if the individual flow rates of each constituent are of primary interest, often their ratios (e.g. water liquid ratio, gas oil ratio) are useful as operational parameters. Total hydrocarbon mass flow rate can be required in particular applications. Constituents other than oil, gas and water flow rates or ratios of these are not dealt with in this document.

The performance of a multiphase flow meter in terms of uncertainty, repeatability and range is of great importance, as this enables the user to compare different meters and evaluate their suitability for use in specific applications. Clause 8 covers this issue in detail and proposes standard methods to describe performance.

Testing and qualification of MPFMs are required to verify performance. Guidance is provided to help optimize the outcome of such activities. Since MPFMs measure at line conditions, the primary output is individual flow rates and fractions at actual conditions (i.e. at the operating pressure and temperature). Conversion of these actual flow rates to flow rates at standard conditions requires knowledge of composition and mass transfer between the liquid and the gas phases, which can require sampling.

The clauses logically proceed from an introduction to multiphase flow measurement, via selection of technology, design considerations and performance specifications, to field installation and commissioning, and finally the operation of MPFMs.

The definitions in Clause 3 have been extended and split into definitions relating to multiphase flows in a closed conduit (see 3.1) and definitions relating to metrology that can be useful in characterizing the performance of a multiphase flow meter.

Clause 5 provides a general introduction to multiphase flows. This clause includes extended descriptions of flow regimes and slip effects in multiphase flows.

Clause 6 covers the aims of multiphase flow measurement, giving the reasoning for selection, installation and operation of multiphase flow metering systems in various applications.

Clause 7 presents guidelines for designing MPFM installations using the two-phase flow map and the composition map.

Standardized performance specification of MPFMs is essential, both for comparison of measuring ranges and measurement uncertainties, but also for more efficient selection of technology (Clause 8).

Clause 9 covers all aspects of testing, calibration and adjustment of MPFMs.

Clause 10 provides recommended procedures and practices for field installation and commissioning of MPFMs. Although MPFMs cannot easily be sent to a test facility for recalibration, there is a need for regular testing to verify the meter performance.

The purpose of Clause 11 is to provide guidelines on how to verify meter performance in the field during operation, assuming no test separator is readily available.

Annex A includes brief descriptions of the most commonly used measurement principles in MPFMs currently available on the market. Guidance on selection of technology and maintenance requirements is also provided. Annex B gives relevant information on hydrocarbon phase behaviour.

Aspects of safety are not dealt with in this document. It is the responsibility of the user to ensure that the system meets applicable safety regulations.

Measurement of multiphase fluid flow

1 Scope

This document establishes a common basis for, and assistance in, the classification of applications and multiphase meters, as well as guidance and recommendations for the implementation and use of such meters.

The so-called in-line multiphase flow meters (MPFMs) that directly measure the oil, water and gas flow rates, as well as the partial- and full-separation MPFMs are the main focus of this document. Conventional two- or three-phase separators are not included in this document. Only limited reference is made to wet-gas meters, since although wet-gas flow is a subset of multiphase flow, wet-gas measurement is covered by ISO/TR 11583 and ISO/TR 12748.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms related to multiphase flow metering

3.1.1
actual conditions
meter *in-situ* process operating conditions of pressure and temperature, at which measured flow rates are reported, without conversion to a standard or reference fluid state

3.1.2
composition map
graph with *gas volume fraction* (3.1.9) and *water liquid ratio* (3.1.42) along the x- and y-axis, respectively

Note 1 to entry: Both the GVF and WLR are at *actual conditions* (3.1.1).

3.1.3
dispersed flow
flow where a particular *phase* (3.1.23) is broken up into multiple small bubbles or droplets carried within the body of another phase

Note 1 to entry: Examples of such flows are bubble flow and mist flow.

3.1.4
emulsion
colloidal mixture of two immiscible fluids, one being dispersed in the other in the form of fine droplets

Note 1 to entry: In multiphase fluids, discrimination should be made between oil-in-water emulsion and water-in-*oil* (3.1.21) emulsion; they respond differently to permittivity measurements.