STANDARDS RELATING TO MEASUREMENT OF PETROLEUM FOR FISCAL PURPOSES AND FOR CALCULATION OF CO_2-TAX

12/5/2004	Final document	1
18/3/2012	Final document	2
Date		**Revision number**
	NORWEGIAN PETROLEUM DIRECTORATE	**Distribution** **Open**

Foreword

This revision of the document is the result of a project carried out for the Norwegian Petroleum Directorate by Didier Pabois of Cirrus Metrology through North Blaze (M) Sdn Bhd by Stig Arvid Knutsson. Contact in NPD has been Steinar Vervik. He has contributed significantly to the layout and content of this report.

Revision of this document

It is our intention to keep this document updated. Any comments or proposals relevant for improvements or information about new standards, updates of standards or new relevant areas of concern would therefore be appreciated.

Comments can be sent to Steinar Vervik, NPD (Steinar.Vervik@npd.no)

Revision history

Revision 1: First edition, 2004
Revision 2: Second edition, 2012

Drafts issued for comments from the NORSOK measurement standards editing committee.

General Standards and Requirements
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General Standards and Requirements
Introduction

This document describes the most used standards regarding fiscal measurement including multiphase measurement for allocation purposes in Norway. The document lists the standards area by area. Consequently when looking for a standard regarding online density measurement for crude, you should go to the chapter "Liquid measurements systems" subchapter "Density".

This document is meant to reference the most common standards for each topic. However, there may be other standards that can be used even if not listed here. For liquid hydrocarbons, main focus is on hydrocarbons also being liquid at atmospheric conditions.

The ISO standards are referred to as ISO nnnn:yyyy where yyyy is the year of issuing the valid revision of the standard from ISO. This can be confusing since CEN may adopt the standard at a later date. As an example ISO 6551:1982 is identical with EN-NS-ISO 6551:1995. In this document the year of issuing the standard refers to the ISO revision year.

A common setup is used for all the chapters in this document. In each of these chapters you will find the following paragraphs and content:

NPD regulations

This chapter references significant paragraphs for the topic in the following NPD regulations:

Regulations relating to measurement of petroleum for fiscal purposes and for calculation of CO2 tax.

In general, only paragraphs discussing the instrument/topic directly are referenced.

NORSOK references

This chapter references paragraphs in the following NORSOK standards, significant for the topic of the current chapter.

I-104 Fiscal Measurement systems for Hydrocarbon Gas (1998)

I-105 Fiscal Measurement systems for Hydrocarbon Liquids (1998)

The Norsok standards I-104 and I-105 are currently (2004) under revision.

This document does not refer specifically to which of the two NORSOK standards it is referred to since this should be clear from the main topic (liquid or gas) in this document.

Comments to the NORSOK metering standards**:**

The NORSOK metering standards are based on international standards, and were developed to define how a metering system can be designed to satisfy NPD regulations. The goal for the development was to

replace oil company specifications and other industry guidelines and documents in order to simplify the work for the manufacturers. The NORSOK standards include specifications for both Fiscal measurement systems, systems for ownership allocation purposes and simpler systems to be used for marginal fields where high accuracy systems can not be justified due to economical considerations and cost/benefit analyses.

The NORSOK standards frequently refer to international standards and indicate how such standards can be fulfilled. However, NORSOK within a few areas, also specifies simpler solutions than those specified in the international standards, where such simplifications can be accepted in Norwegian developments. One such area is calibration and testing of gas chromatographs where an alternative method is described.

Most significant standards

This chapter has references to national and international standards grouped by the individual standardization organization. Only standardization organizations with relevant standards are listed.

This list of standards is, however, not meant to be a complete list of standards for the topic. Consequently there can be other standards for each topic that may be important for a particular project or used by individual companies, even if not mentioned here.

Comments

In this chapter we have included comments to the use of individual standards and possibly comments to individual standards revision history if found significant.

For most topics, however, this paragraph is empty and marked “None”.

Abstracts of standards

In this chapter we have presented an abstract of each of the “most significant standards”. Most abstracts presented in this document are abstracts taken from the standardization organizations internet catalog or through participation in standardization commities. For the remaining standards the abstract is a summary of the standard scope and introduction.

Other relevant standards

Other less significant standards for each topic are mentioned in the paragraph. When no standards are listed this chapter is left blank.

TIP: regarding other related standards

To find even more standards related to each topic, you can follow the “procedure” below.:

1. Start from one of the listed standards
2. From one of the standard organization web sites or the PRONORM web site, find the topic ICS code or the ISO subcommittee by searching for one of the known standards.
3. Start a new search and search for the ICS code/ subcommittee work. All standards in that group will then be listed and thereby the most related standards to the topic are the starting point for the search.

General Standards and Requirements

Measurement Units – Reference Conditions

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 9: Units of measurement
Section 10: Reference conditions

NORSOK References

No specific standards

Most Significant Standards

ISO Standards

ISO 5024: 1999	Petroleum liquids and liquefied petroleum gases - Measurement - Standard reference conditions
ISO 13443: 1996	Natural gas - Standard reference conditions
ISO 13443: 1996/Cor 1:1997	
ISO 80000-1: 2009	Quantities and Units – Part 1 : General
ISO/IEC Guide 99: 2007	International vocabulary of metrology - Basic and general concepts and associated terms (VIM)

Abstract of standards

ISO 5024:1999 “Petroleum liquids and liquefied petroleum gases - Measurement - Standard reference conditions” defines different standard reference conditions, important for calculation of standard volume, heating value …

ISO 13443:1996 “Natural gas - Standard reference conditions” specifies the standard reference conditions of temperature, pressure and humidity to be used for measurements and calculations carried out on natural gases and similar fluids.

ISO 80000-1:2009 “Quantities and Units – Part 1 : General” gives general information and definitions concerning quantities, systems of quantities, units, quantity and unit symbols, and coherent unit systems, especially the International System of Quantities, ISQ, and the International System of Units, SI.

The principles laid down in ISO 80000-1:2009 are intended for general use within the various fields of science and technology and as an introduction to other parts of the Quantities and units series.

ISO/IEC Guide 99:2007 "International vocabulary of metrology - Basic and general concepts and associated terms (VIM)" provides a set of definitions and associated terms, for a system of basic and general concepts used in metrology, together with concept diagrams to demonstrate their relations. Additional information is given in the form of examples and notes under many definitions. This Vocabulary is meant to be a common reference for scientists and engineers, as well as teachers and practitioners, involved in planning or performing measurements, irrespective of the level of measurement uncertainty and irrespective of the field of application. It is also meant to be a reference for governmental and inter-governmental bodies, trade associations, accreditation bodies, regulators and professional societies.

Other relevant Standards

API-MPMS 15: 2007 Guidelines for Use of the International System of Units (SI) in the Petroleum and Allied Industries.

API-MPMS Chapter 15: 2007 "Guidelines for Use of the International System of Units (SI) in the Petroleum and Allied Industries" specifies the API preferred units for quantities involved in petroleum industry measurements and indicates factors for conversion of quantities expressed in customary units to the API-preferred metric units. The quantities that comprise the tables are grouped into convenient categories related to their use. They were chosen to meet the needs of the many and varied aspects of the petroleum industry but also should be useful in similar process industries.

General Standards and Requirements

Quality Management

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 5: Management control system

NORSOK References

No specific standards

Most Significant Standards

ISO Standards

ISO 9000: 2005	Quality management systems -- Fundamentals and vocabulary
ISO 9001: 2008	Quality management systems - Requirements
ISO 20815: 2008	Petroleum, petrochemical and natural gas industries - Production assurance and reliability management

Abstract of standards

ISO 9000:2005 “Quality management systems - Fundamentals and vocabulary “describes fundamentals of quality management systems, which form the subject of the ISO 9000 family, and defines related terms.

It is applicable to the following:

a) organizations seeking advantage through the implementation of a quality management system;
b) organizations seeking confidence from their suppliers that their product requirements will be satisfied;
c) users of the products;
d) those concerned with a mutual understanding of the terminology used in quality management (e.g. suppliers, customers, regulators);
e) those internal or external to the organization who assess the quality management system or audit it for conformity with the requirements of ISO 9001 (e.g. auditors, regulators, certification/registration bodies);
f) those internal or external to the organization who give advice or training on the quality management system appropriate to that organization;
g) developers of related standards.

ISO 9001: 2008 “Quality management systems – Requirements” specifies requirements for a quality management system where an organization needs to demonstrate its ability to consistently provide product that meets customer and applicable statutory and regulatory requirements, and aims to enhance customer satisfaction through the effective application of the system, including

processes for continual improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.

All requirements of ISO 9001:2008 are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.

Where any requirement(s) of ISO 9001:2008 cannot be applied due to the nature of an organization and its product, this can be considered for exclusion.

Where exclusions are made, claims of conformity to ISO 9001:2008 are not acceptable unless these exclusions are limited to requirements within Clause 7, and such exclusions do not affect the organization's ability, or responsibility, to provide product that meets customer and applicable statutory and regulatory requirements.

ISO 20815:2008 "Petroleum, petrochemical and natural gas industries - Production assurance and reliability management" introduces the concept of production assurance within the systems and operations associated with exploration drilling, exploitation, processing and transport of petroleum, petrochemical and natural gas resources. ISO 20815:2008 covers upstream (including subsea), midstream and downstream facilities and activities. It focuses on production assurance of oil and gas production, processing and associated activities and covers the analysis of reliability and maintenance of the components. It provides processes and activities, requirements and guidelines for systematic management, effective planning, execution and use of production assurance and reliability technology. This is to achieve cost-effective solutions over the life cycle of an asset-development project structured around the following main elements: production-assurance management for optimum economy of the facility through all of its life-cycle phases, while also considering constraints arising from health, safety, environment, quality and human factors; planning, execution and implementation of reliability technology; application of reliability and maintenance data; and reliability-based design and operation improvement. For standards on equipment reliability and maintenance performance in general, see the IEC 60300-3 series. ISO 20815:2008 designates 12 processes, of which seven are defined as core production-assurance processes and addressed in ISO 20815:2008. The remaining five processes are denoted as interacting processes and are outside the scope of ISO 20815:2008. The interaction of the core production-assurance processes with these interacting processes, however, is within the scope of ISO 20815:2008 as the information flow to and from these latter processes is required to ensure that production-assurance requirements can be fulfilled. ISO 20815:2008 recommends that the listed processes and activities be initiated only if they can be considered to add value.

The only requirements mandated by ISO 20815:2008 are the establishment and execution of the production-assurance programme (PAP).

Other relevant Standards

ISO 9004: 2009	Managing for the sustained success of an organization – A quality management approach.
ISO 10005: 2005	Quality management systems - Guidelines for quality plans
ISO/TR 10013: 2001	Guidelines for quality management system documentation
ISO 19011: 2002	Guidelines for quality and/or environmental management systems auditing

ISO/TS 29001: 2010 Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations

ISO 9004:2009 “Managing for the sustained success of an organization - A quality management approach” provides guidance to organizations to support the achievement of sustained success by a quality management approach. It is applicable to any organization, regardless of size, type and activity.

ISO 9004:2009 is not intended for certification, regulatory or contractual use.

ISO 10005:2005 “Quality management systems - Guidelines for quality plans” provides guidelines for the development, review, acceptance, application and revision of quality plans. It is applicable whether or not the organization has a management system in conformity with ISO 9001. It is applicable to quality plans for a process, product, project or contract, any product category (hardware, software, processed materials and services) and any industry. It is focused primarily on product realization and is not a guide to organizational quality management system planning. ISO 10005:2005 is a guidance document and is not intended to be used for certification or registration purposes.

ISO 19011:2002 “Guidelines for quality and/or environmental management systems auditing” provides guidance on the principles of auditing, managing audit programmes, conducting quality management system audits and environmental management system audits, as well as guidance on the competence of quality and environmental management system auditors. It is applicable to all organizations needing to conduct internal or external audits of quality and/or environmental management systems or to manage an audit programme. The application of ISO 19011 to other types of audits is possible in principle provided that special consideration is paid to identifying the competence needed by the audit team members in such cases.

ISO/TS 29001:2010 “Petroleum, petrochemical and natural gas industries -- Sector-specific quality management systems -- Requirements for product and service supply organizations” defines the quality management system for product and service supply organizations for the petroleum, petrochemical and natural gas industries. Boxed text is original ISO 9001:2008 text unaltered and in its entirety. The petroleum, petrochemical, and natural gas industry sector-specific supplemental requirements are outside the boxes.

General Standards and Requirements

Third Party Calibration and Testing Laboratories

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 11: Determination of energy content etc .
Section 19: General (calibration)
Section 21: Calibration of instrument part
Section 23: Maintenance
Section 31: Calibration documents

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.4: General requirements – Calibration
Annex B: (Normative) Testing and Commissioning

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.4: General requirements – Calibration
Annex B: (Normative) Testing and Commissioning

Most Significant Standards

ISO Standards

ISO/IEC 17025: 2005	General requirements for the competence of testing and calibration laboratories

Abstract of standards

ISO/IEC 17025:2005 “General requirements for the competence of testing and calibration laboratories” specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling. It covers testing and calibration performed using standard methods, non-standard methods, and laboratory-developed methods. It is applicable to all organizations performing tests and/or calibrations. These include, for example, first-, second- and third-party laboratories, and laboratories where testing and/or calibration forms part of inspection and product certification. ISO/IEC 17025:2005 is applicable to all laboratories regardless of the number of personnel or the extent of the scope of testing and/or calibration activities. When a laboratory does not undertake one or more of the activities covered by ISO/IEC 17025:2005, such as sampling and the design/development of new methods, the requirements of those clauses do not apply. ISO/IEC 17025:2005 is for use by laboratories in developing their management system

for quality, administrative and technical operations. Laboratory customers, regulatory authorities and accreditation bodies may also use it in confirming or recognizing the competence of laboratories. ISO/IEC 17025:2005 is not intended to be used as the basis for certification of laboratories. Compliance with regulatory and safety requirements on the operation of laboratories is not covered by ISO/IEC 17025:2005.

Other relevant Standards

ISO/IEC 17021: 2011	Conformity assessment -- Requirements for bodies providing audit and certification of management systems
ISO/IEC Guide 28: 2004	Conformity assessment -- Guidance on a third-party certification system for products

ISO/IEC 17021:2011 “Conformity assessment - Requirements for bodies providing audit and certification of management systems” contains principles and requirements for the competence, consistency and impartiality of the audit and certification of management systems of all types (e.g. quality management systems or environmental management systems) and for bodies providing these activities. Certification bodies operating to ISO/IEC 17021:2011 need not offer all types of management system certification. Certification of management systems is a third-party conformity assessment activity. Bodies performing this activity are therefore third-party conformity assessment bodies.

ISO/IEC Guide 28:2004 “Conformity assessment - Guidance on a third-party certification system for products” gives general guidelines for a specific product certification system. It is applicable to a third-party product certification system for determining the conformity of a product with specified requirements through initial testing of samples of the product, assessment and surveillance of the involved quality system, and surveillance by testing of product samples taken from the factory or the open market, or both. ISO/IEC Guide 28:2004 addresses conditions for use of a mark of conformity and conditions for granting a certificate of conformity.

General Standards and Requirements

Uncertainty

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 8a: Allowable measurement uncertainty for measuring systems for liquids other than water
Section 15: Maintenance
Section 16: The computer part of the metering system
Section 20: Calibration of mechanical part
Section 23: Maintenance
Section 28: Documentation prior to start up of the metering system

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.2: General requirements – Uncertainty
Section 5.1.2: Sales and allocation measurement – Functional requirements – Products/Services
Section 5.1.4.1: Sales and allocation measurement – Functional requirements – Performances – Capacity
Section 5.1.4.2: Sales and allocation measurement – Functional requirements – Performances – Uncertainty
Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part – Meter runs and header design
Section 5.2.2.4: Sales and allocation measurement – Technical requirements - Mechanical part – Flowmeter design
Section 5.2.3.6: Sales and allocation measurement – Technical requirements - Instrument part – Temperature loop
Section 5.2.3.8: Sales and allocation measurement – Technical requirements - Instrument part – Direct density measurement
Section 6.1.4.2: Fuel gas measurement – Functional requirements - Performance – Uncertainty
Section 7.1.4.2: Flare gas measurement – Functional requirements - Performance – Uncertainty
Section 9.1.4.1: Gas chromatograph – Functional requirements - Performance – Uncertainty
Section 9.2.4: Gas chromatograph – Technical requirements – Calibration equipment
Annex C: (Informative) System selection criteria

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.2: General requirements – Uncertainty
Section 5.1.4.1: Sales and allocation measurement – Functional requirements – Performances – Capacity
Section 5.1.4.2: Sales and allocation measurement – Functional requirements – Performances – Uncertainty

Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Flowmeter design
Section 5.2.3.2: Sales and allocation measurement – Technical requirements – Mechanical part, prover unit - Conventional pipe prover
Section 5.2.3.3: Sales and allocation measurement – Technical requirements – Mechanical part, prover unit - Compact prover
Section 5.2.4.5: Sales and allocation measurement – Technical requirements – Instrument part – Temperature loop
Section 5.2.4.7: Sales and allocation measurement – Technical requirements – Instrument part – Density
Section 6.1.4.1: Water in oil measurement – Functional requirements – Performance – Capacity
Section 6.1.4.2: Water in oil measurement – Functional requirements – Performance – Uncertainty
Section 7.1.4.2: Oil sampler systems – Functional requirements – Performance – Uncertainty
Annex C: (Informative) System selection criteria

Most Significant Standards

ISO Standards

ISO/IEC Guide 98-1: 2009	Uncertainty of measurement -- Part 1: Introduction to the expression of uncertainty in measurement
ISO/IEC Guide 98-3: 2008	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

NFOGM Standards

NFOGM 2001	Handbook of uncertainty calculation, Ultrasonic Fiscal Gas Metering Station
NFOGM 2003	Handbook of uncertainty calculation, Fiscal Orifice Gas and Turbine Oil Metering Station

Abstract of standards

ISO/IEC Guide 98-1:2009 “Uncertainty of measurement -- Part 1: Introduction to the expression of uncertainty in measurement” provides a brief introduction to the “Guide to the expression of uncertainty in measurement” (GUM) in order to indicate the relevance of that fundamental guide and promote its use. It also outlines documents related to the GUM that are intended to extend the application of that guide to broader categories and fields of practical problems. ISO/IEC Guide 98-1:2009 addresses measurement science at a level that is suitable for those readers who have received training at least to the second year of a science- or engineering-based degree course containing some teaching of probability theory and statistics. It also considers various concepts used in measurement science. In particular, it covers the need to characterize the quality of a measurement through appropriate statements of measurement uncertainty. This introductory document also outlines the recent evolution of thinking regarding measurement uncertainty.

ISO/IEC Guide 98-3:2008 "Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM: 1995)" is a reissue of the 1995 version of the Guide to the Expression of Uncertainty in Measurement (GUM), with minor corrections. This Guide establishes general rules for evaluating and expressing uncertainty in measurement that can be followed at various levels of accuracy and in many fields — from the shop floor to fundamental research. The principles of this Guide are intended to be applicable to a broad spectrum of measurements, including those required for:

- maintaining quality control and quality assurance in production;
- complying with and enforcing laws and regulations;
- conducting basic research, and applied research and development, in science and engineering;
- calibrating standards and instruments and performing tests throughout a national measurement system in order to achieve traceability to national standards;
- developing, maintaining, and comparing international and national physical reference standards, including reference materials.

NFOGM 2001: "Handbook of uncertainty calculation, Ultrasonic Fiscal Gas Metering Station" is accompanied with an Excel program that provides a practical approach to the field of uncertainty calculations for ultrasonic fiscal gas metering stations. The document is primarily written for experienced users and operators of fiscal gas metering stations as well as manufacturers of ultrasonic gas flow meters and engineering personnel.

NFOGM 2003: "Handbook of uncertainty calculation, Fiscal Orifice Gas and Turbine Oil Metering Station" is a handbook and spread sheet that can be used to calculate the system uncertainty. The handbook is based on the GUM. (ISO report Guide to the expression of uncertainty in measurement). The spread sheets, one for orifice meters and one for turbine meter stations, consist of a number of pages covering all single instruments used in the respective metering station.

Other relevant Standards

ISO/IEC NP Guide 98-2 (1)	Uncertainty of measurement - Part 2: Concepts and basic principles
ISO/IEC NP Guide 98-4 (1)	Uncertainty of measurement - Part 4: Role of measurement uncertainty in conformity assessment
ISO/IEC NP Guide 98-5 (1)	Uncertainty of measurement - Part 5: Applications of the least-squares method
ISO/DTR 13587 (1)	Three statistical approaches for the assessment and interpretation of measurement uncertainty
ISO 5168:2005	Measurement of fluid flow - Procedures for the evaluation of uncertainties
ISO 6974-1: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 1: Guidelines for tailored analysis
ISO 6974-2: 2001	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 2: Measuring-system characteristics and statistics for processing of data

ISO 6974-3: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns
ISO 6974-4: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 4: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns
ISO 6974-5: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 5: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns
ISO 6974-6: 2002	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 6: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns
ISO/TR 7066-1: 1997	Assessment of uncertainty in calibration and use of flow measurement devices - Part 1: Linear calibration relationships
ISO 7066-2: 1988	Assessment of uncertainty in the calibration and use of flow measurement devices - Part 2: Non-linear calibration relationships
ISO 21748: 2010	Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation
ISO/IEC Guide 98-3 Suppl 1: 2008	Propagation of distributions using a Monte Carlo method.
API MPMS 13.1: 2011	Statistical Concepts and Procedures in Measurement
API MPMS 13.2: 2011	Statistical Methods of Evaluating Meter Proving Data

(1): Not published at time of edition.

ISO 5168:2005 “Measurement of fluid flow -- Procedures for the evaluation of uncertainties” establishes general principles and describes procedures for evaluating the uncertainty of a fluid flow-rate or quantity. A step-by-step procedure for calculating uncertainty is given.

ISO 6974-1: 2000 “Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 1: Guidelines for tailored analysis “ gives guidelines for the quantitative analysis of natural-gas-containing constituents within the application ranges given in Table 1. Individual methods, as described in part 3 and subsequent parts of ISO 6974, may have more restricted application ranges than those in Table 1, but in all cases they will fall within this overall scope of the ranges given.

Table 1 — Application ranges

Component	Mole fraction range %
Hydrogen	0,001 to 0,5
Helium	0,001 to 0,5
Oxygen	0,001 to 5
Nitrogen	0,001 to 60
Carbon dioxide	0,001 to 35
Methane	40 to 100
Ethane	0,02 to 15
Propane	0,001 to 25
Butanes	0,000 1 to 5
Pentanes	0,000 1 to 1
Hexanes and heavier	0,000 1 to 0,5

ISO 6974-2: 2001 “Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 2: Measuring-system characteristics and statistics for processing of data” describes the data processing for the tailored analysis of natural gas. It includes the determination of the measuring system characteristics and the statistical approach to data handling and error calculation with the aim of defining the uncertainty in the mole fractions of the component measured. This part of ISO 6974 is only applicable in conjunction with part 1 of ISO 6974.

ISO 6974-3: 2000 “Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns” describes a gas chromatographic method for the quantitative determination of the content of helium, hydrogen, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons in natural gas samples using two packed columns. This method is applicable to determinations made in on-line processes or in the laboratory. It is applicable to the analysis of gases containing constituents within the mole fraction ranges given in Table 1 and which do not contain any hydrocarbon condensate. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be detected present, the method can still be applicable. This part of ISO 6974 is only applicable in conjunction with parts 1 and 2 of ISO 6974.

Table 1 — Application ranges

Component	Mole fraction range %
Helium	0,01 to 0,5
Hydrogen	0,01 to 0,5
Oxygen	0,1 to 0,5
Nitrogen	0,1 to 40
Carbon dioxide	0,1 to 30
Methane	50 to 100
Ethane	0,1 to 15
Propane	0,001 to 5
Butanes	0,000 1 to 2
Pentanes	0,000 1 to 1
Hexanes to octanes	0,000 1 to 0,5

ISO 6974-4: 2000 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 4: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns" describes a gas chromatographic method for the quantitative determination of natural gas constituents using a two-column system. This method is applicable to determinations made in on-line processes or in the laboratory. It is applicable to the analysis of gases containing constituents within the mole fraction ranges given in Table 1. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be detected present, the method can still be applicable. This part of ISO 6974 is only applicable if used in conjunction with parts 1 and 2 of ISO 6974.

Table 1 — Application ranges

Component	Mole fraction range %
Nitrogen	0,001 to 15,0
Carbon dioxide	0,001 to 10
Methane	75 to 100
Ethane	0,001 to 10,0
Propane	0,001 to 3,0
iso-Butane (2-methylpropane)	0,001 to 1,0
n-Butane	0,001 to 1,0
neo -Pentane (2,2-dimethylpropane)	0,001 to 0,5
iso -Pentane (2-methylbutane)	0,001 to 0,5
n-Pentane	0,001 to 0,5
Hexanes _ sum of all C6 and higher hydrocarbons	0,001 to 0,2

ISO 6974-5: 2000 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 5: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns" describes a gas chromatographic method for the quantitative determination of natural gas constituents using a

three-column system. This method is applicable to natural gases of limited range, on-line and automatically calibrating on a regular basis for gas samples not containing any hydrocarbon condensate and/or water. It is applicable to the analysis of gases containing constituents within the mole fraction ranges given in Table 1. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be detected present, the method can still be applicable. This part of ISO 6974 is only applicable if used in conjunction with parts 1 and 2 of ISO 6974.

Table 1 — Application ranges

Component	Mole fraction range %
Nitrogen	0,001 to 15,0
Carbon dioxide	0,001 to 8,5
Methane	75 to 100
Ethane	0,001 to 10,0
Propane	0,001 to 3,0
iso-Butane (2-methylpropane)	0,001 to 1,0
n-Butane	0,001 to 1,0
neo -Pentane (2,2-dimethylpropane)	0,001 to 0,5
iso-Pentane (2-methylbutane)	0,001 to 0,5
n-Pentane	0,001 to 0,5
Hexanes _ sum of all C6 and higher hydrocarbons	0,001 to 1,0

ISO 6974-6: 2002 “Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 6: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns” describes a gas chromatographic method for the quantitative determination of the content of helium, hydrogen, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons in natural gas samples using three capillary columns. This method is applicable to the determination of these gases within the mole fraction ranges varying from 0,000 1 % to 40 %, depending on the component analyzed, and is commonly used for laboratory applications. However, it is only applicable to methane within the mole fraction range of 40 % to 100 %. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be present at detectable levels, the method can still be applicable. ISO 6974-6:2002 is only applicable if used in conjunction with ISO 6974-1:2000 and ISO 6974-2:2001. This method can also be applicable to the analysis of natural gas substitutes. Additional information on the applicability of this method to the determination of natural gas substitutes is also given where relevant.

ISO/TR 7066-1:1997 “Assessment of uncertainty in calibration and use of flow measurement devices -- Part 1: Linear calibration relationships” describes the procedures to be used in deriving the calibration curve for methods of measuring the flowrate in closed conduits or open channels, and for assessing the uncertainty associated with such calibrations. Replaces the first edition published as an International Standard (ISO 7066-1).

ISO 7066-2:1988 “Assessment of uncertainty in the calibration and use of flow measurement devices -- Part 2: Non-linear calibration relationships” describes the procedures for fitting a quadratic, cubic or higher degree polynomial expression to a non-linear set of calibration data, using the least-squares criterion, and of assessing the uncertainty associated with the resulting calibration curve. The method of fitting a straight line to flow measurement calibration data is dealt with in ISO 7066-1.

ISO 21748:2010 “Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation” gives guidance for evaluation of measurement uncertainties using data obtained from studies conducted in accordance with ISO 5725-2:1994; comparison of collaborative study results with measurement uncertainty (MU) obtained using formal principles of uncertainty propagation. (ISO 5725-3:1994 provides additional models for studies of intermediate precision. However, while the same general approach may be applied to the use of such extended models, uncertainty evaluation using these models is not incorporated in ISO 21748:2010.) ISO 21748:2010 is applicable in all measurement and test fields where an uncertainty associated with a result has to be determined. It does not describe the application of repeatability data in the absence of reproducibility data. ISO 21748:2010 assumes that recognized, non-negligible systematic effects are corrected, either by applying a numerical correction as part of the method of measurement, or by investigation and removal of the cause of the effect. The recommendations in ISO 21748:2010 are primarily for guidance. It is recognized that while the recommendations presented do form a valid approach to the evaluation of uncertainty for many purposes, it is also possible to adopt other suitable approaches. In general, references to measurement results, methods and processes in ISO 21748:2010 are normally understood to apply also to testing results, methods and processes.

ISO/IEC Guide 98-3:2008/Suppl 1:2008 “Propagation of distributions using a Monte Carlo method” provides a general numerical approach, consistent with the broad principles of the Guide to the expression of uncertainty in measurement (GUM), for carrying out the calculations required as part of an evaluation of measurement uncertainty. The approach applies to arbitrary models having a single output quantity where the input quantities are characterized by any specified probability density functions (PDFs). ISO/IEC Guide 98-3/Suppl.1:2008 is primarily concerned with the expression of uncertainty in the measurement of a well-defined physical quantity—the measurand—that can be characterized by an essentially unique value. It provides guidance in situations where the conditions for the GUM uncertainty framework are not fulfilled, or it is unclear whether they are fulfilled. It can be used when it is difficult to apply the GUM uncertainty framework, because of the complexity of the model, for example. Guidance is given in a form suitable for computer implementation. ISO/IEC Guide 98-3/Suppl.1:2008 can be used to provide (a representation of) the PDF for the output quantity from which (a) an estimate of the output quantity, (b) the standard uncertainty associated with this estimate, and (c) a coverage interval for that quantity, corresponding to a specified coverage probability, can be obtained. For a prescribed coverage probability, it can be used to provide any required coverage interval, including the probabilistically symmetric coverage interval and the shortest coverage interval. ISO/IEC Guide 98-3/Suppl.1:2008 applies to input quantities that are independent, where each such quantity is assigned an appropriate PDF, or not independent, i.e. when some or all of these quantities are assigned a joint PDF. Detailed examples illustrate the guidance provided.

API MPMS 13.1: 2011 “Statistical Concepts and Procedures in Measurement” designed to help those who make measurement of bulk oil quantities improve the value of their result statement by making proper estimates of the uncertainty or probable error involved in measurements.

API MPMS 13.2: 2011 “Statistical Methods of Evaluating Meter Proving Data” addresses procedures for evaluating any meter's performance where meter proving factors are developed in accordance with Chapter 12.2. The data in examples used in this chapter are intended to be typical of custody transfer operations of low-vapor-pressure fluids using displacement or turbine meters in accordance with Chapters 4, 5, and 6 of API's Manual of Petroleum Measurement Standards. However, the procedures in Chapter 13.2 can be used for noncustody transfer metering applications and for custody transfer metering of high -vapor-pressure and gaseous fluids where meter proving data are available.

Liquid Measurement System
General

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

All sections

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

All sections

Most Significant Standards

ISO Standards

ISO 1998-6: 2000	Petroleum industry -- Terminology -- Part 6: Measurement
ISO 11631: 1998	Measurement of fluid flow -- Methods of specifying flowmeter performance

OIML Recommendation

R117-1: 2007	Dynamic measurement systems for liquids other than water

API Standards

API MPMS 5.1: 2008	General Considerations for Measurement by Meters

Abstract of standards

ISO 1998-6:2000 “Petroleum industry -- Terminology -- Part 6: Measurement “ introduces a list of equivalent English and French terms, in use in the petroleum industry to indicate the measurement of crude oils and petroleum products, together with the corresponding definitions in the two languages. ISO 1998 is intended to cover the purposes of this part of petroleum industry dealing with crude oils and petroleum products that means all related operations arising from the production field to the final user. It is not intended to cover either petroleum equipment, or any operation in the field. However some pieces of equipment or some operations of exploration and production are defined. The corresponding terms were introduced only when they appear in a definition of a product or process and when their definition was found necessary for understanding or for avoiding any ambiguity.

ISO 11631:1998 “Measurement of fluid flow -- Methods of specifying flowmeter performance” applies to technical specifications and descriptions issued by manufacturers of flowmeters. It specifies methods of describing the performance of any flowmeter, for use in either closed conduits or open channels. It indicates how flowmeters may be classified according to their traceability group, and specifies how manufacturer's statements on traceability, quality assurance and conditions of use should be expressed, although further statements may be required for other conditions of use.

OIML R117-1:2007 specifies the metrological and technical requirements applicable to dynamic measuring systems for quantities (volume or mass) of liquids other than water subject to legal metrology controls. It also provides requirements for the approval of parts of the measuring systems (meter, etc.).

API MPMS 5.1:2008 “General Considerations for Measurement by Meters” Intended to be a guide for the proper specification, installation, and operation of meter runs designed to dynamically measure liquid hydrocarbons so that acceptable accuracy, service life, safety, reliability, and quality control can be achieved. API MPMS Chapter 5 also includes information that will assist in troubleshooting and improving the performance of meters.

Other relevant Standards

ISO 91-1: 1992 (2)	Petroleum measurement tables -- Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F
ISO 91-2: 1991 (2)	Petroleum measurement tables -- Part 2: Tables based on a reference temperature of 20 degrees C
ISO 2714: 1980	Liquid hydrocarbons -- Volumetric measurement by displacement meter systems other than dispensing pumps
ISO 2715: 1981	Liquid hydrocarbons -- Volumetric measurement by turbine meter systems
ISO 4124: 1994	Liquid hydrocarbons -- Dynamic measurement -- Statistical control of volumetric metering systems
ISO 9770: 1989	Crude petroleum and petroleum products -- Compressibility factors for hydrocarbons in the range 638 kg/m^3 to 1 074 kg/m^3
ISO 10790: 1999	Measurement of fluid flow in closed conduits -- Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)
API MPMS 5.2: 2005	Measurement of Liquid Hydrocarbons by Displacement Meters
API MPMS 5.3: 2009	Measurement of Liquid Hydrocarbons by Turbine Meters
API MPMS 5.6: 2008	Measurement of Liquid Hydrocarbons by Coriolis Meters
API MPMS 5.8: 2005	Measurement of Liquid Hydrocarbons by Ultrasonic Flowmeters Using Transit Time Technology

(2): Under revision at time of edition.

ISO 91-1:1992 “Petroleum measurement tables - Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F” refers to petroleum measurement tables published by the American Petroleum Institute (API, USA), the American Society for Testing and Materials (ASTM, USA)

and the Institute of Petroleum (IP, UK) and subsidiary documents, correcting the printing errors in these publications, based on reference temperatures of 15 °C and 60 °F. The standard reference temperature for petroleum measurement adopted in IS0 5024 is 15 °C, and should be used for international trade. However, it is recognized that its use is not yet universally accepted and references to tables based on 60 °F have therefore been included in IS0 91-1:1992 and tables based on 20 °C are covered in IS0 91-2.

ISO 91-2:1991 “Petroleum measurement tables - Part 2: Tables based on a reference temperature of 20 degrees C” refers to computer implementation procedures for the correction of densities and volumes to the reference temperature of 20°C. This first edition cancels and replaces ISO/TR 91:1970/Add.1:1975. Annex A is for information only.

ISO 2714:1980 “Liquid hydrocarbons -- Volumetric measurement by displacement meter systems other than dispensing pumps” gives the characteristics of such equipment and rules for systematically applying appropriate consideration to the nature of the liquids to be measured, to the installation of a metering system, and to the selection, performance, operation and maintenance of the same.

ISO 2715:1981 “Liquid hydrocarbons -- Volumetric measurement by turbine meter systems” gives the characteristics of such equipment and rules for systematically applying appropriate consideration to the nature of the liquids to be measured, to the installation of a metering system, and to the selection, performance, operation and maintenance of the same.

ISO 4124:1994 “Liquid hydrocarbons -- Dynamic measurement -- Statistical control of volumetric metering systems”. In dynamic measuring systems the performance of meters for liquid hydrocarbons will vary with changes in flow conditions, viz. flowrate, viscosity, temperature, pressure, density of product, and with mechanical wear. Has been prepared as a guide for establishing and monitoring the performance of such meters, using appropriate statistical control procedures for both central and on-line proving. These procedures may be applied to measurements made by any type of volumetric or mass metering systems. The procedures to be followed for collecting data, on which the control limits are based, are described.

ISO 9770:1989 “Crude petroleum and petroleum products -- Compressibility factors for hydrocarbons in the range 638 kg/m3 to 1 074 kg/m3” includes the contents of Manual of Petroleum Measurement Standards, Chapter 11.2.1M published August 1984 by API. The purpose is to correct hydrocarbon volumes metered under pressure to the corresponding volumes at the equilibrium pressure for the metered temperature. Contains compressibility factors related to meter temperature and density of metered material.

ISO 10790:1999 “Measurement of fluid flow in closed conduits - Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)” gives guidelines for the selection, installation, calibration, performance and operation of Coriolis meters for the determination of mass flow, density, volume flow and other related parameters of fluids. It also gives appropriate considerations regarding the fluids to be measured.

API MPMS 5.2: 2005 “Measurement of Liquid Hydrocarbons by Displacement Meters” together with the general considerations for measurement by meters found in API MPMS Chapter 5.1, describes methods for obtaining accurate quantity measurement with displacement meters in liquid hydrocarbon service. It covers the unique performance characteristics of displacement meters in liquid hydrocarbon service. It does not apply to the measurement of two-phase fluids.

API MPMS 5.3: 2009 “Measurement of Liquid Hydrocarbons by Turbine Meters” defines the application criteria for turbine meters and discusses appropriate considerations regarding the liquids to be measured. Discusses the installation of a turbine metering system; and the performance, operation, and maintenance of turbine meters in liquid hydrocarbon service. Includes "Selecting a Meter and Accessory Equipment" and information on the recommended location for prover connections.

API MPMS 5.6: 2008 “Measurement of Liquid Hydrocarbons by Coriolis Meters” describes methods for achieving custody transfer levels of accuracy when a Coriolis meter is used to measure liquid hydrocarbons. Topics covered include: applicable API standards used in the operation of Coriolis meters; proving and verification using both mass- and volume based methods; installation, operation, and maintenance. Both mass and volume-based calculation procedures for proving and quantity determination are included in Appendix E.

API MPMS 5.8: 2005 “Measurement of Liquid Hydrocarbons by Ultrasonic Flowmeters Using Transit Time Technology” describes methods for obtaining custody transfer level measurements with ultrasonic flow meters (UFMs) used to measure liquid hydrocarbons. This document includes application criteria for UFM and includes considerations regarding the liquids being measured. This document also address the installation, operation, proving and maintenance of UFMs in liquid hydrocarbon service.

Liquid Measurement Systems
Turbine Meter

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 14: The mechanical part of the metering system
Section 25: Operating requirements for flow meters

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Flowmeter design
Annex A: (Normative) Requirements for automated condition based maintenance
Annex F: (Normative) Statistical evaluation of repeatability

Most Significant Standards

ISO Standards

ISO 2715: 1981	Liquid hydrocarbons -- Volumetric measurement by turbine meter systems
ISO 6551: 1982	Petroleum liquids and gases -- Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data

API Standards

API MPMS 5.3: 2009	Measurement of Liquid Hydrocarbons by Turbine Meters
API MPMS 5.4: 2005	Accessory Equipment for Liquid Meters
API MPMS 5.5: 2010	Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems

Abstract of standards

ISO 2715:1981 “Liquid hydrocarbons -- Volumetric measurement by turbine meter systems” gives the characteristics of such equipment and rules for systematically applying appropriate consideration to the nature of the liquids to be measured, to the installation of a metering system, and to the selection, performance, operation and maintenance of the same.

ISO 6551: 1982 “Petroleum liquids and gases - Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data” establishes guidelines for ensuring the quantities stated, a main objective being to ensure the integrity of the primary indication. In order to achieve different levels of security, criteria and recommendations for the design, installation, use and maintenance of the relevant equipment are laid down. Regulatory requirements, including those for safety, are not specifically covered in detail but certain general cautionary notes on safety are included for guidance.

API MPMS 5.3:2009 “Measurement of Liquid Hydrocarbons by Turbine Meters” defines the application criteria for turbine meters and discusses appropriate considerations regarding the liquids to be measured. Discusses the installation of a turbine metering system; and the performance, operation, and maintenance of turbine meters in liquid hydrocarbon service. Includes "Selecting a Meter and Accessory Equipment" and information on the recommended location for prover connections.

API MPMS 5.4:2005 “Accessory Equipment for Liquid Meters” describes the characteristics of accessory equipment used with displacement and turbine meters in liquid hydrocarbon service. Includes guidance on the use of electronic flow computers.

API MPMS 5.5: 2010 “Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems” serves as a guide for the selection, operation, and maintenance of various types of pulsed-data, cabled transmission systems for fluid metering systems to provide the desired level of fidelity and security of transmitted flow pulse data. This publication does not endorse or advocate the preferential use of any specific type of equipment or systems, nor is it intended to restrict future development of such equipment.

Other relevant Standards

Liquid Measurement Systems
Positive Displacement Meter

NPD Regulations

No specific reference

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Flowmeter design

Most Significant Standards

ISO Standards

ISO 2714: 1980	Liquid hydrocarbons -- Volumetric measurement by displacement meter systems other than dispensing pumps
ISO 6551: 1982	Petroleum liquids and gases -- Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data

API Standards

API MPMS 5.2: 2010	Measurement of Liquid Hydrocarbons by Displacement Meters
API MPMS 5.4: 2005	Accessory Equipment for Liquid Meters
API MPMS 5.5: 2010	Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems

Abstract of standards

ISO 2714:1980 “Liquid hydrocarbons -- Volumetric measurement by displacement meter systems other than dispensing pumps” gives the characteristics of such equipment and rules for systematically applying appropriate consideration to the nature of the liquids to be measured, to the installation of a metering system, and to the selection, performance, operation and maintenance of the same.

ISO 6551: 1982 “Petroleum liquids and gases - Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data” establishes guidelines for ensuring the quantities stated, a main objective being to ensure the integrity of the primary indication. In order to achieve different levels of security, criteria and recommendations for the design, installation, use and maintenance of the relevant equipment are laid down. Regulatory requirements, including those for safety, are not specifically covered in detail but certain general cautionary notes on safety are included for guidance.

API MPMS 5.2:2010 “Measurement of Liquid Hydrocarbons by Displacement Meters” together with the general considerations for measurement by meters found in API MPMS Chapter 5.1, describes methods for obtaining accurate quantity measurement with displacement meters in liquid hydrocarbon service. It covers the unique performance characteristics of displacement meters in liquid hydrocarbon service. It does not apply to the measurement of two-phase fluids.

API MPMS 5.4:2005 “Accessory Equipment for Liquid Meters” describes the characteristics of accessory equipment used with displacement and turbine meters in liquid hydrocarbon service. Includes guidance on the use of electronic flow computers.

API MPMS 5.5: 2010 “Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems” serves as a guide for the selection, operation, and maintenance of various types of pulsed-data, cabled transmission systems for fluid metering systems to provide the desired level of fidelity and security of transmitted flow pulse data. This publication does not endorse or advocate the preferential use of any specific type of equipment or systems, nor is it intended to restrict future development of such equipment.

Other relevant Standards

Liquid Measurement Systems
Coriolis Meter

NPD Regulations

No specific reference

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Flowmeter design
Annex F: (Normative) Statistical evaluation of repeatability

Most Significant Standards

ISO Standards

ISO 10790: 1999	Measurement of fluid flow in closed conduits -- Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)
ISO 6551: 1982	Petroleum liquids and gases -- Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data

API Standards

API MPMS 5.6: 2008	Measurement of Liquid Hydrocarbons by Coriolis Meters
API MPMS 5.4: 2005	Accessory Equipment for Liquid Meters
API MPMS 5.5: 2010	Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems

Abstract of standards

ISO 10790:1999 “Measurement of fluid flow in closed conduits - Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)” gives guidelines for the selection, installation, calibration, performance and operation of Coriolis meters for the determination of mass flow, density, volume flow and other related parameters of fluids. It also gives appropriate considerations regarding the fluids to be measured.

ISO 6551: 1982 “Petroleum liquids and gases - Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data” establishes guidelines for ensuring the quantities stated, a main objective being to ensure the integrity of the primary indication. In order

to achieve different levels of security, criteria and recommendations for the design, installation, use and maintenance of the relevant equipment are laid down. Regulatory requirements, including those for safety, are not specifically covered in detail but certain general cautionary notes on safety are included for guidance.

API MPMS 5.6:2008 “Measurement of Liquid Hydrocarbons by Coriolis Meters” describes methods for achieving custody transfer levels of accuracy when a Coriolis meter is used to measure liquid hydrocarbons. Topics covered include: applicable API standards used in the operation of Coriolis meters; proving and verification using both mass- and volume based methods; installation, operation, and maintenance. Both mass and volume-based calculation procedures for proving and quantity determination are included in Appendix E.

API MPMS 5.4:2005 “Accessory Equipment for Liquid Meters” describes the characteristics of accessory equipment used with displacement and turbine meters in liquid hydrocarbon service. Includes guidance on the use of electronic flow computers.

API MPMS 5.5: 2010 “Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems” serves as a guide for the selection, operation, and maintenance of various types of pulsed-data, cabled transmission systems for fluid metering systems to provide the desired level of fidelity and security of transmitted flow pulse data. This publication does not endorse or advocate the preferential use of any specific type of equipment or systems, nor is it intended to restrict future development of such equipment.

Other relevant Standards

Liquid Measurement Systems
Ultrasonic Meter

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 25: Operating requirements for flow meters

NORSOK References

NORSOK Standard I-105: 2007 "Fiscal measurement systems for hydrocarbon liquid"

Section 5.1.8: Sales and allocation measurement – Functional requirements – Layout requirements
Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Flowmeter design
Section 5.2.2.8: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Thermal insulation
Section 5.2.4.8: Sales and allocation measurement – Technical requirements – Instrument part – Ultrasonic flowmeter
Section 5.2.5.6: Sales and allocation measurement – Technical requirements – Computer part – Check
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning
Annex F: (Normative) Statistical evaluation of repeatability

Most Significant Standards

ISO Standards

ISO/DIS 12242 (1)	Measurement of fluid flow in closed conduits - Ultrasonic meters for liquid
ISO 6551: 1982	Petroleum liquids and gases -- Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data

(1): Not published at time of edition.

API Standards

API MPMS 5.8: 2005	Measurement of Liquid Hydrocarbons by Ultrasonic Flowmeters Using Transit Time Technology
API MPMS 5.4: 2005	Accessory Equipment for Liquid Meters

API MPMS 5.5: 2010 Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems

Abstract of standards

ISO 6551: 1982 “Petroleum liquids and gases - Fidelity and security of dynamic measurement - Cabled transmission of electric and/or electronic pulsed data” establishes guidelines for ensuring the quantities stated, a main objective being to ensure the integrity of the primary indication. In order to achieve different levels of security, criteria and recommendations for the design, installation, use and maintenance of the relevant equipment are laid down. Regulatory requirements, including those for safety, are not specifically covered in detail but certain general cautionary notes on safety are included for guidance.

API MPMS 5.8:2005 “Measurement of Liquid Hydrocarbons by Ultrasonic Flowmeters Using Transit Time Technology” describes methods for obtaining custody transfer level measurements with ultrasonic flow meters (UFMs) used to measure liquid hydrocarbons. This document includes application criteria for UFM and includes considerations regarding the liquids being measured. This document also address the installation, operation, proving and maintenance of UFMs in liquid hydrocarbon service.

API MPMS 5.4:2005 “Accessory Equipment for Liquid Meters” describes the characteristics of accessory equipment used with displacement and turbine meters in liquid hydrocarbon service. Includes guidance on the use of electronic flow computers.

API MPMS 5.5: 2010 “Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems” serves as a guide for the selection, operation, and maintenance of various types of pulsed-data, cabled transmission systems for fluid metering systems to provide the desired level of fidelity and security of transmitted flow pulse data. This publication does not endorse or advocate the preferential use of any specific type of equipment or systems, nor is it intended to restrict future development of such equipment.

Other relevant Standards

Liquid Measurement Systems

Prover

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 14: The mechanical part of the metering system
Section 20: Calibration of mechanical part
Section 24: Operational requirement for the prover
Section 25: Operational requirement for flow meters

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 5.1.3: Sales and allocation measurement – Functional requirements – Equipment/Schematic
Section 5.1.6.1: Sales and allocation measurement – Functional requirements – Operational requirements - General
Section 5.1.7.2: Sales and allocation measurement – Functional requirements – Maintenance requirements – Calibration
Section 5.1.7.4: Sales and allocation measurement – Functional requirements – Maintenance requirements – Isolation and sectioning
Section 5.2.2.3: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Flowmeter design
Section 5.2.2.4: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Block valves
Section 5.2.3.1: Sales and allocation measurement – Technical requirements – Mechanical part, prover Unit - General
Section 5.2.3.2: Sales and allocation measurement – Technical requirements – Mechanical part, prover Unit – Conventional pipe prover
Section 5.2.3.3: Sales and allocation measurement – Technical requirements – Mechanical part, prover Unit – Compact prover
Section 5.2.4.1: Sales and allocation measurement – Technical requirements – Instrument part – Location of sensors
Section 5.2.5.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning
Annex F: (Normative) Statistical evaluation of repeatability

Most Significant Standards

ISO Standards

ISO 7278-1: 1987	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters -- Part 1: General principles
ISO 7278-2: 1988	Liquid hydrocarbons - Dynamic measurement -- Proving systems for volumetric meters -- Part 2: Pipe provers
ISO 7278-3: 1998	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters -- Part 3: Pulse interpolation techniques
ISO 7278-4: 1999	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 4: Guide for operators of pipe provers

API Standards

API MPMS 4.1: 2009	Proving system - Introduction
API MPMS 4.2: 2003	Proving system - Displacement provers
API MPMS 4.4: 2010	Proving system - Tank provers
API MPMS 4.5: 2005	Proving system - Master Meter provers
API MPMS 4.6: 2008	Proving system - Pulse interpolation
API MPMS 4.7: 2009	Proving system - Field Standard Test Measures
API MPMS 4.8: 2007	Proving system - Operation of Proving Systems

Abstract of standards

ISO 7278-1:1987 “Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 1: General principles”. The purpose of proving a meter is to determine its relative error or its meter factor as a function of flow rate and other parameters such as temperature, pressure and viscosity. The following types of proving systems are in use: tank prover systems; pipe provers, bidirectional and unidirectional; master meters. They can be used either connected (fixed or mobile) to the metering station or in a central proving station.

ISO 7278-2:1988 “Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 2: Pipe provers” provides guidance for the design, installation and calibration of these provers. Calculation techniques for use when calibrating and operating provers are detailed in ISO 4267-2. Most of the material is general in that it applies to provers for use with different liquids and types of meters and for proving them in different services. Does not apply to the newer "small volume" or "compact" provers.

ISO 7278-3:1998 “Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 3: Pulse interpolation techniques”. The use of pipe provers to prove meters with pulsed outputs requires that a minimum number of pulses be collected during the proving period. The number of pulses which a meter can produce during a proving run is often limited to significantly less than 10 000 pulses. Therefore, in many applications some means of increasing the meter’s resolution has to be found. One way of overcoming this problem is to process the signal from the

meter in such a way that the resolution of the meter is increased. This technique is known as pulse interpolation. This part of ISO 7278 applies primarily to pipe provers, but it is not intended to restrict in any way the future development of different methods of pulse interpolation to this and other applications.

ISO 7278-4:1999 "Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 4: Guide for operators of pipe provers". This part of ISO 7278 is concerned with only one class of provers, known as pipe provers, which are used very widely where meters for crude oil and petroleum products have to be proved to the highest possible standards of accuracy. In principle, a pipe prover is only a length of pipe or a cylinder whose internal volume has been measured very accurately and having a well-fitted piston (or a tightly-fitted sphere acting like a piston) inside it, so that the volume swept out by the piston or sphere can be compared with the meter readout while a steady flow of liquid is passing through the meter and prover in series. In practice, however, various accessories must be added to the simple pipe-and-piston arrangement to produce a prover that will work effectively.

API MPMS 4.1:2009 "Proving system – Introduction". General introduction to the subject of proving. The requirements in Chapter 4 are based on customary practices that evolved for crude oils and products covered by API MPMS Chapter 11.1. The prover and meter uncertainties should be appropriate for the measured fluids and should be agreeable to the parties involved.

API MPMS 4.2:2003 "Proving system – Displacement provers" outlines the essential elements of provers that accumulate meter pulses as a displacing element within the prover travels between detector switches. It provides design and installation details for the types of displacement provers that are currently in use. The provers discussed are designed for proving measurement devices under dynamic operating conditions with single-phase liquid hydrocarbons.

API MPMS 4.4:2010 "Proving system - Tank provers" specifies the characteristics of tank provers that are in general use and the procedures for their calibration. This standard does not apply to weir-type, vapor-condensing, dual-tank water-displacement, or gas-displacement provers.

API MPMS 4.5:2005 "Proving system - Master Meter provers" covers the use of both displacement and turbine meters as master meters.

API MPMS 4.6:2008 "Proving system - Pulse interpolation" describes how the double-chronometry method of pulse interpolation, including system operating requirements and equipment testing, is applied to meter proving.

API MPMS 4.7:2009 "Proving system - Field Standard Test Measures" details the essential elements of field standard test measures by providing descriptions, construction requirements, as well as inspection, handling, and calibration methods. Bottom-neck scale test measures and prover tanks are not addressed in this document. The scope of this standard is limited to the certification of "delivered volumes" of test measures.

API MPMS 4.8:2007 "Proving system - Operation of Proving Systems" covers the operation of various meter-proving systems used in the petroleum industry. Liquid petroleum meters used for custody transfer measurement require periodic proving to verify accuracy and repeatability and to establish valid meter factors.

Other relevant Standards

ISO 8222:2002 Petroleum measurement systems - Calibration -- Temperature corrections for use when calibrating volumetric proving tanks

ISO 8222:2002 "Petroleum measurement systems - Calibration - Temperature corrections for use when calibrating volumetric proving tanks '' specifies multiplication factors for the correction of the volume of water transferred from a primary measure to a tank for changes arising from temperature differences during the determination of the capacity of the tank at reference temperature.

Liquid Measurement Systems
Static Measurement of Refrigerated Gases

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements – General
Section 4.2: General requirements – Uncertainty
Section 5.2.5.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Section 5.1.7.2: Sales and allocation measurement - Functional requirements - Maintenance requirements - Calibration
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning

Most Significant Standards

ISO 18132-1:2011	Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels -- General requirements for automatic tank gauges Part 1: Automatic tank gauges for liquefied natural gas on board marine carriers and floating storage
ISO 18132--2: 2011	ISO 18132-2:2008 Refrigerated light hydrocarbon fluids -- General requirements for automatic level gauges . Part 2: Gauges in refrigerated-type shore tanks.

Abstract of standards

ISO 18132-1:2011 establishes general principles for the accuracy, installation, calibration and verification of automatic tank gauges (ATGs) used for custody transfer measurement of liquefied natural gas (LNG) on board an LNG carrier or floating storage.
The LNG described in the standard is either fully refrigerated (i.e. at the cryogenic condition), or partially refrigerated, and therefore the fluid is at or near atmospheric pressure.
ISO 18132-1:2011 also specifies the technical requirements for data collection, transmission and reception. Specific technical requirements for various automatic tank gauges and accuracy limitations are given in the annexes.

ISO 18132-2:2008 establishes the general requirements for the specification, installation and calibration/verification testing of automatic level gauges (ALG) used for refrigerated light hydrocarbon fluids, i.e., LNG and LPG, stored in bulk storage tanks on shore at pressures close to atmosphere.

Other relevant Standards

STANDARDS RELATING TO MEASUREMENT OF PETROLEUM

Liquid Measurement Systems
Sampling

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 11: Determination of energy content, etc …
Section 17: Requirements relating to sampling
Section 20: Calibration of mechanical part
Section 24: Operational requirement for the prover
Section 25: Operational requirement for flow meters

NORSOK References

NORSOK Standard I-105: 2007 "Fiscal measurement systems for hydrocarbon liquid"

Section 4.1: General requirements – General
Section 4.3: General requirements – Sampling and water fraction metering equipment
Section 5.1.6.2: Sales and allocation measurement – Functional requirements – Operational requirements - Tanker loading measurement system
Section 5.1.9: Sales and allocation measurement – Functional requirements – Interface requirements
Section 5.2.2.8: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Thermal insulation
Section 7.1.1: Oil sampler systems – Functional requirements – General
Section 7.1.3: Oil sampler systems – Functional requirements – Equipment/Schematic
Section 7.1.4.1: Oil sampler systems – Functional requirements – Performance – Capacity
Section 7.1.9: Oil sampler systems – Functional requirements – Layout requirements
Annex A: (Normative) Requirements for automated condition based maintenance
Annex E: (Informative) Guidelines to implementation of ISO 3171

Most Significant Standards

ISO Standards

ISO 3170: 2004	Petroleum liquids - Manual sampling
ISO 3171: 1988	Petroleum liquids -- Automatic pipeline sampling

API Standards

API MPMS 8.1: 2006	Manual Sampling of Petroleum and Petroleum Products
API MPMS 8.2: 2010	Automatic Sampling of Petroleum and Petroleum Products

Abstract of standards

ISO 3170:2004 “Petroleum liquids - Manual sampling” specifies the manual methods to be used for obtaining samples of liquid or semi-liquid hydrocarbons, tank residues and deposits from fixed tanks, railcars, road vehicles, ships and barges, drums and cans, or from liquids being pumped in pipelines. ISO 3170:2004 applies to the sampling of petroleum products, crude oils and intermediate products, which are stored in tanks at or near atmospheric pressure, or transferred by pipelines, and are handled as liquids at temperatures from near ambient up to 200 degrees Celsius.

ISO 3171:1988 “Petroleum liquids -- Automatic pipeline sampling” recommends procedures for crude oil and liquid petroleum products being conveyed by pipeline. Does not apply to liquefied petroleum gases and liquefied natural gases. The principal purpose is to give guidelines for specifying, testing, operating, maintaining and monitoring crude oil samples.

API MPMS 8.1:2006 “Manual Sampling of Petroleum and Petroleum Products” covers the procedures for obtaining representative samples of shipments of uniform petroleum products, except electrical insulating oils and fluid power hydraulic fluids. It also covers sampling of crude petroleum and non-uniform petroleum products and shipments. It does not cover butane, propane, and gas liquids with a Reid Vapor Pressure (RVP) above 26 psi. The major addition to the standard is a section on extended-tube sampling.

API MPMS 8.2:2010 “Automatic Sampling of Petroleum and Petroleum Products” covers automatic procedures for obtaining representative samples of petroleum and non-uniform stocks or shipments, except electrical insulating oil.

Other relevant Standards

ISO 4257: 2007	Liquefied petroleum gases -- Method of sampling
API MPMS 8.3: 2010	Standard Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
API MPMS 8.4: 2009	Standard Practice for Sampling and Handling of Fuels for Volatility Measurement
API MPMS 13.1: 2011	Statistical Concepts and Procedures in Measurement
API MPMS 13.2: 2011	Statistical Methods of Evaluating Meter Proving Data

API MPMS 8.3:2010 “Standard Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products” covers the handling, mixing, and conditioning procedures required to ensure that a representative sample of the liquid petroleum or petroleum product is delivered from the primary sample container/receiver into the analytical test apparatus or into intermediate containers. For sampling procedures, refer to Chapters 8.1 and 8.2. Refer to Chapter 8.4 for the mixing and handling of light fuels for volatility measurement

API MPMS 8.4:2009 “Standard Practice for Sampling and Handling of Fuels for Volatility Measurement” covers procedures and equipment for obtaining, mixing, and handling representative samples of volatile fuels for the purpose of testing for compliance with the standards set forth for volatility related measurements applicable to light fuels. The applicable dry vapor pressure equivalent range of this practice is 13 to 105 kPa (2 to 16 psia). This practice is applicable to the sampling, mixing, and handling of reformulated fuels including those containing oxygenates.

API MPMS 13.1:2011 “Statistical Concepts and Procedures in Measurement” designed to help those who make measurement of bulk oil quantities improve the value of their result statement by making proper estimates of the uncertainty or probable error involved in measurements.

API MPMS 13.2:2011 “Statistical Methods of Evaluating Meter Proving Data” addresses procedures for evaluating any meter's performance where meter proving factors are developed in accordance with Chapter 12.2. The data in examples used in this chapter are intended to be typical of custody transfer operations of low-vapor-pressure fluids using displacement or turbine meters in accordance with Chapters 4, 5, and 6 of API's Manual of Petroleum Measurement Standards. However, the procedures in Chapter 13.2 can be used for non-custody transfer metering applications and for custody transfer metering of high -vapor-pressure and gaseous fluids where meter proving data are available.

Liquid Measurement Systems
Pressure and Temperature Instruments

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 10: Reference conditions
Section 13: Requirements to the metering system in general
Section 15: The instrument part of metering system
Section 25: Operational requirement for flow meters

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.1: General requirements – General
Section 5.1.2: Sales and allocation measurement - Functional requirements - Products/services
Section 5.1.8: Sales and allocation measurement - Functional requirements – Layout requirements
Section 5.2.2.5: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Meter run flow control
Section 5.2.2.5: Sales and allocation measurement – Technical requirements - Mechanical part, exclusive prover unit – Thermal insulation
Section 5.2.3.1: Sales and allocation measurement – Technical requirements – Mechanical part, prover Unit – General
Section 5.2.4.1: Sales and allocation measurement – Technical requirements – Instrument part – Location of sensor
Section 5.2.4.4: Sales and allocation measurement – Technical requirements – Instrument part – Stability for smart transmitters
Section 5.2.4.5: Sales and allocation measurement – Technical requirements – Instrument part – Temperature loop
Section 5.2.4.6: Sales and allocation measurement – Technical requirements – Instrument part – Thermowell
Section 5.2.4.11: Sales and allocation measurement – Technical requirements – Instrument part – Local pressure indication
Section 5.2.4.14: Sales and allocation measurement – Technical requirements – Instrument part – Enclosures
Section 5.2.5.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Section 7.1.3: Oil sampler – Functional requirements – Equipment/Schematic
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning

Annex D: (Informative) Water in oil calculations
Annex E: (Informative) Guidelines to implementation of ISO 3171

Most Significant Standards

IEC Standard

CEI 60751: 2008 Industrial platinum resistance thermometers and platinum temperature sensors

API Standards

API MPMS 7: 2007 Temperature Determination

Abstract of standards

CEI 60751:2008 “Industrial platinum resistance thermometers and platinum temperature sensors” specifies the requirements and temperature/resistance relationship for industrial platinum resistance temperature sensors later referred to as “platinum resistors” or "resistors" and industrial platinum resistance thermometers later referred to as "thermometers" whose electrical resistance is a defined function of temperature.

API MPMS 7:2007 “Temperature determination” describes methods and practices that may be used to obtain accurate measurements of temperature of petroleum and petroleum products in pipelines, storage tanks, gathering tanks, ships, barges, tank cars, pipe provers, tank provers and test measures under both static and dynamic conditions using electronic temperature measuring devices or mercury-in glass thermometers. Describes the methods, equipment, and procedures for determining the temperature of petroleum and petroleum products under both static and dynamic conditions. This chapter discusses temperature measurement requirements in general for custody transfer, inventory control, and marine measurements. The actual method and equipment selected for temperature determination are left to the agreement of the parties involved.

Other relevant Standards

ISO 8310: 1991 Refrigerated light hydrocarbon fluids - Measurement of temperature in tanks containing liquefied gases - Resistance thermometers and thermocouples

ISO 8310:1991 “Refrigerated light hydrocarbon fluids - Measurement of temperature in tanks containing liquefied gases - Resistance thermometers and thermocouples” specifies the essential requirements and verification procedures for sensors, thermocouples and associated equipment to be used for ship and shore tanks containing hydrocarbon fluids. Annexes A and B are for information only.

Liquid Measurement Systems

Density

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 15: The instrument part of metering system
Section 25: Operational requirement for flow meters
Section 26: Operating requirements for instrument part

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.3: General requirements – Sampling and water fraction metering equipment
Section 5.1.6.1: Sales and allocation measurement - Functional requirements - Operational requirements – General
Section 5.2.4.1: Sales and allocation measurement – Technical requirements – Instrument part – Location of sensor
Section 5.2.4.7: Sales and allocation measurement – Technical requirements – Instrument part – Density
Section 5.2.5.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Section 5.2.5.5: Sales and allocation measurement – Technical requirements – Computer part – Calculations
Section 5.2.5.6: Sales and allocation measurement – Technical requirements – Computer part – Check
Annex A: (Normative) Requirements for automated condition based maintenance
Annex D: (Informative) Water in oil calculations

Most Significant Standards

ISO Standards

ISO 3838: 2004	Crude petroleum and liquid or solid petroleum products - Determination of density or relative density - Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods
ISO 15212-1: 2008	Oscillation-type density meters -- Part 1: Laboratory instruments
ISO 15212-2: 2008	Oscillation-type density meters -- Part 2: Process instruments for homogeneous liquids

API Standards

API MPMS 9.1: 2005	Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

Abstract of standards

ISO 3838:2004 “Crude petroleum and liquid or solid petroleum products -- Determination of density or relative density -- Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods” specifies methods for the determination of the density or relative density of crude petroleum and of petroleum products handled as liquids. The capillary-stoppered pyknometer method is also for use with solids and this method may also be used for coal tar products, including road tars, creosote and tar pitches, or for mixtures of these with petroleum products. This method is not suitable for the determination of the density or relative density of highly volatile liquids having Reid vapour pressures greater than 50 kPa according to ISO 3007 or having an initial boiling point below 40 degrees Celsius. The graduated bicapillary pyknometer method is recommended for the accurate determination of the density or relative density of all except the more viscous products, and is particularly useful. when only small amounts of samples are available. The method is restricted to liquids having Reid vapour pressures of 130 kPa or less according to ISO 3007 and having kinematic viscosities less than 50 mm2/s (50 centistokes (cSt)) at the test temperature. Special precautions are specified for the determination of the density or relative density of highly volatile liquids.

API MPMS 9.1:2005 “Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method” describes the methods and practices relating to the determination of the density, relative density, or API gravity of crude petroleum and liquid petroleum products using the hydrometer method (laboratory determination).

Other relevant Standards

ISO 3675: 1998	Crude petroleum and liquid petroleum products - Laboratory determination of density - Hydrometer method
ISO 3993: 1984	Liquefied petroleum gas and light hydrocarbons - Determination of density or relative density - Pressure hydrometer method
ISO 10790: 1999	Measurement of fluid flow in closed conduits - Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)
ISO 12185: 1996	Crude petroleum and petroleum products - Determination of density - Oscillating U-tube method
API MPMS 9.2: 2007	Standard Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer
API MPMS 9.3: 2008	Standard Test Method for Density, Relative Density, and API Gravity of Crude Petroleum and Liquid Petroleum Products by Thermohydrometer Method

ISO 3993:1984 “Liquefied petroleum gas and light hydrocarbons -- Determination of density or relative density -- Pressure hydrometer method”. The prescribed apparatus shall not be used for materials having gauge vapour pressures higher than 1,4 MPa (absolute vapour pressure 1,5 MPa) at the test temperature. Alternative calibration procedures are described, but only the one using a certified hydrometer is suitable for the determination of density to be used in calculations of qualities for custody transfer or fiscal purposes.

ISO 10790:1999 “Measurement of fluid flow in closed conduits - Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)” gives guidelines for the selection, installation, calibration, performance and operation of Coriolis meters for the determination of mass flow, density, volume flow and other related parameters of fluids. It also gives appropriate considerations regarding the fluids to be measured.

ISO 12185:1996 “Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method” gives a method for the determination, using an oscillation U-tube densitometer, of the density of crude petroleum and related products within the range 600 kg/m^3 to 1 100 kg/m^3 which can be handled as single-phase liquids at the test temperature and pressure.

API MPMS 9.2:2007 “Standard Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer” provides a guide for determining the density or relative density (specific gravity) or API gravity of light hydrocarbons, including liquefied petroleum gases, using a pressure hydrometer.

API MPMS 9.3:2008 “Standard Test Method for Density, Relative Density, and API Gravity of Crude Petroleum and Liquid Petroleum Products by Thermohydrometer Method” describes methods and practices suitable for the determination of density or API gravity of crude petroleum and liquid petroleum products using thermohydrometers. The test method covers petroleum and liquid petroleum products with Reid vapor pressure of 179 kPa (26 psi) or less.

Liquid Measurement Systems
Water and Sediments

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.1: General requirements – General
Section 4.3: General requirements – Sampling and water fraction metering equipment
Section 6: Water in oil measurement
Section 6.1.1: Water in oil measurement – Functional requirements – General
Section 6.1.4.1: Water in oil measurement – Functional requirements – Performance - Capacity
Section 6.1.4.2: Water in oil measurement – Functional requirements – Performance – Uncertainty
Section 6.1.5: Water in oil measurement – Functional requirements – Process/Ambient conditions
Section 6.1.6: Water in oil measurement – Functional requirements – Operational requirements
Section 6.1.7.3: Water in oil measurement – Functional requirements – Maintenance requirements – Layout requirements
Section 6.2.1: Water in oil measurement – Technical requirements – Mechanical part
Section 6.2.2: Water in oil measurement – Technical requirements – Instrument part
Section 6.2.3: Water in oil measurement – Technical requirements – Computer part
Annex D: (Informative) Water in oil calculations

Most Significant Standards

ISO Standards

ISO 9030: 1990	Crude petroleum - Determination of water and sediment - Centrifuge method

API Standards

API MPMS 10.3: 2008	Standard Test Method for Water and Sediment in Crude Oil by the Centrifuge Method (Laboratory Procedure)
API MPMS 10.4: 2010	Determination of Sediment and Water in Crude Oil by the Centrifuge Method (Field Procedure)
API MPMS TR 2570: 2010	Continuous on-line Measurement of Water In Petroleum (Crude Oil and Condensate)

Abstract of standards

ISO 9030:1990 "Crude petroleum - Determination of water and sediment - Centrifuge method" Specifies a method for the laboratory determination. The precision data of this procedure have only been determined for water contents up to 1 % (V/V). Includes principle, apparatus, reagents, sampling, procedure, expression of results, precision and test report. A centrifuge tube is shown in figure 1. The procedure for reading the volume of water and sediment is shown in figure 2. The precision of the method is shown in figure 3. The sample handling is described in annex A.

API MPMS 10.3:2008 "Standard Test Method for Water and Sediment in Crude Oil by the Centrifuge Method (Laboratory Procedure)" describes a method of laboratory determination of water and sediment in crude oil by means of the centrifuge procedure

API MPMS 10.4:2010 "Determination of Sediment and Water in Crude Oil by the Centrifuge Method (Field Procedure)" describes a method for determining both water and sediment or sediment only in crude oils using the field centrifuge procedure.

API MPMS TR 2570:2010 "Continuous on-line Measurement of Water In Petroleum (Crude Oil and Condensate)" Provides guidance for the application, installation, operation, verification, and proving of on-line water devices (OWDs) for use in the non-custody transfer measurement of water in crude oil and condensate.

Other relevant Standards

ISO 3734: 1997	Petroleum products - Determination of water and sediment in residual fuel oils - Centrifuge method
ISO 3735: 1999	Crude petroleum and fuel oils - Determination of sediment - Extraction method
ISO 10307-1: 2009	Petroleum products - Total sediment in residual fuel oils - Part 1: Determination by hot filtration
ISO 10307-2: 2009	Petroleum products - Total sediment in residual fuel oils - Part 2: Determination using standard procedures for ageing
API MPMS 10.1: 2007	Standard Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method
API MPMS 10.2: 2007	Standard Test Method for Water in Crude Oil by Distillation
API MPMS 10.5: 2005	Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
API MPMS 10.6: 2004	Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
API MPMS 10.7: 2006	Standard Test Method for Water in Crude Oils by Potentiometric Karl Fischer Titration
API MPMS 10.8: 2010	Standard Test Method for Sediment in Crude Oil by Membrane Filtration
API MPMS 10.9: 2010	Standard Test Method for Water in Crude Oils by Coulometric Karl Fischer Titration
NFOGM Handbook 2005	Handbook of Water Fraction Metering

ISO 10307-1: 2009 "Petroleum products - Total sediment in residual fuel oils - Part 1: Determination by hot filtration" specifies a method for the determination of total sediment in residual fuel oils having a maximum viscosity of 55 mm^2/s at 100 °C, and for blends of distillate fuels containing residual components.

ISO 10307-2: 2009 "Petroleum products - Total sediment in residual fuel oils - Part 2: Determination using standard procedures for ageing" specifies two procedures — A (thermal) and B (chemical) — for the accelerated ageing of residual fuel oils. When combined with the hot filtration method specified in ISO 10307-1, these procedures permit the prediction of fuel oil stability, as affected by sedimentation, during storage and handling of the fuel oils.

API MPMS 10.1: 2007 "Standard Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method" covers the determination of sediment in crude oils and fuel oils by extraction with toluene. The precision applies to a range of sediment levels from 0.01 to 0.40 % mass, although higher levels may be determined.

API MPMS 10.2: 2007 "Standard Test Method for Water in Crude Oil by Distillation" specifies a method for the determination of water in crude petroleum by distillation.

API MPMS 10.5: 2005 "Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation" covers the determination of water in the range from 0 to 25 % volume in petroleum products, tars, and other bituminous materials by the distillation method.

API MPMS 10.6: 2004 "Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)" describes the laboratory determination of water and sediment in fuel oils in the range from 0 to 30 % volume by means of the centrifuge procedure.

API MPMS 10.7: 2006 "Standard Test Method for Water in Crude Oils by Potentiometric Karl Fischer Titration" describes the procedure for the determination of water in crude oils by Karl Fischer titration (potentiometric.) This test method covers the determination of water in the range from 0.02 to 2 mass percent in crude oils. Mercaptan and sulfide (S^{-} or H2S) sulfur are known to interfere with the method.

API MPMS 10.8: 2010 "Standard Test Method for Sediment in Crude Oil by Membrane Filtration" covers the determination of sediment in crude oils by membrane filtration. This test method has been validated for crude oils with sediments up to approximately 0.15 mass %. The accepted unit of measure for this test method is mass %, but an equation to convert to volume % is provided.

API MPMS 10.9: 2010 "Standard Test Method for Water in Crude Oils by Coulometric Karl Fischer Titration" covers the determination of water in the range from 0.02 to 5.0 percent in crude oils. The test method presents two procedures for the direct determination of water content in crude oils; weight and volume.

NFOGM Handbook 2005 "Handbook of Water Fraction Metering" sets out recommendations to be used for the continuous determination of water fraction in hydrocarbon liquids. It describes the recommended installation, calibration and adjustment methods. The procedures and installations described have been prepared for both fiscal and allocation water fraction measurements. As integral part of the work undertaken by Christian Michelsen Research for revision 1 of this handbook, a scientific evaluation of the theoretical uncertainty for two different WFMs was carried out. Both the Fluenta WIOM-350 (no longer marketed) [1] and the MFI Water Cut Meter (now marketed as the Roxar WaterCut Meter) [2] underwent a theoretical evaluation of the combined uncertainty in accordance with the "Guide to the expression of uncertainty in measurement" [3]. The recommendations outlined in this handbook are based on these reports. The problems of multiphase mixtures are pointed out and the precautions for minimizing them are described. However, it should be noted that all fiscal aspects of this handbook are founded on the base line conditions that the flow has no water slugs and that the water and oil are homogeneously distributed.

Liquid Measurement Systems
Viscosity

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 25: Operating requirements for flow meters

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.1: General requirements – General
Annex B: (Normative) Testing and commissioning

Most Significant Standards

No specific Standards for on line viscosity measurement

Other relevant Standards

ASTM D341-03	Standard Test Method for Viscosity-Temperature Charts for Liquid Petroleum Products
ISO 2909: 2002	Petroleum products -- Calculation of viscosity index from kinematic viscosity

ASTM D341-03 “Standard Test Method for Viscosity-Temperature Charts for Liquid Petroleum Products”. The kinematic viscosity-temperature charts covered by this standard are a convenient means to ascertain the kinematic viscosity of a petroleum oil or liquid hydrocarbon at any temperature within a limited range, provided that the kinematic viscosities at two temperatures are known.

ISO 2909:2002 “Petroleum products -- Calculation of viscosity index from kinematic viscosity” describes two procedures for calculating the viscosity index (VI) of petroleum products and related materials, such as lubricating oils, from their kinematic viscosities at 40 °C and 100 °C. Procedure A is applicable to petroleum products of viscosity index up to and including 100. Procedure B is applicable to petroleum products of viscosity index 100 or greater. ISO 2909:2002 does not apply to petroleum products with kinematic viscosities less than 2,0 mm^2/s at 100 °C. It applies to petroleum products with kinematic viscosities between 2 mm^2/s and 70 mm^2/s at 100 °C. Equations are provided for calculating the viscosity index of petroleum products having kinematic viscosities above 70 mm^2/s at 100 °C.

Liquid Measurement Systems
Flow Computer and Calculations

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 14: The mechanical part of the metering system
Section 15: The instrument part of the metering system
Section 16: The computer part of metering system
Section 21: Calibration of instrument part
Section 22: Verification of computer part
Section 27: Operating requirements for computer part
Section 29: Documentation relating to the metering system in operation
Section 30: Information

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.2: General requirements - Uncertainty
Section 4.4: General requirements - Calibration
Section 5.1.3: Sales and allocation measurement - Functional requirements - Equipment/schematic
Section 5.1.7.2: Sales and allocation measurement - Functional requirements - Maintenance requirements – Calibration
Section 5.2.4.7: Sales and allocation measurement - Technical requirements - Instrument part - Density
Section 5.2.5.2: Sales and allocation measurement - Technical requirements - Computer part - Computer design
Section 5.2.5.5: Sales and allocation measurement - Technical requirements - Computer part - Calculations
Section 5.2.5.9: Sales and allocation measurement - Technical requirements - Computer part - Reporting of data for continuous measurement system
Section 5.2.5.13: Sales and allocation measurement - Technical requirements - Computer part - Availability
Section 5.2.5.14: Sales and allocation measurement - Technical requirements - Computer part - Network protection/security
Section 5.2.5.15: Sales and allocation measurement - Technical requirements - Computer part - Spare capacity
Section 5.2.5.17: Sales and allocation measurement - Technical requirements - Computer part - Downloading of constants and ranges
Section 6.1.5: Water in oil measurement - Functional requirements - Process/ambient conditions
Section 6.1.8: Water in oil measurement - Functional requirements - Interface requirements

Section 6.1.9: Water in oil measurement - Functional requirements - Testing and commissioning requirements
Section 6.2.3: Water in oil measurement - Technical requirements - Computer part
Section 7.1.1.4: Oil sampler systems - Functional requirements – Performance – Availability
Annex B: (Normative) Testing and commissioning
Annex D: (Informative) Water in oil calculations
Annex F: (Normative) Statistical evaluation of repeatability

Most Significant Standards

ISO Standards

ISO 91-1: 1992 (2)	Petroleum measurement tables -- Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F
ISO 91-2: 1991 (2)	Petroleum measurement tables -- Part 2: Tables based on a reference temperature of 20 degrees C
ISO 4267-2: 1988	Petroleum and liquid petroleum products - Calculation of oil quantities - Part 2: Dynamic measurement
ISO 9770: 1989	Crude petroleum and petroleum products -- Compressibility factors for hydrocarbons in the range 638 kg/m^3 to 1 074 kg/m^3

(2): Under revision at time of edition.

API Standards

API MPMS 11.1: 2004	Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils
API MPMS 11.2.2: 2007	Compressibility Factors for Hydrocarbons: 0.350–0.637 Relative Density (60 °F/60 °F) and –50 °F to 140 °F Metering Temperature
API MPMS 11.2.2M: 2007	Compressibility Factors for Hydrocarbons: 350–637 Kilograms per Cubic Meter Density (15 °C) and –46 °C to 60 °C Metering Temperature
API MPMS 12.2.1: 2009	Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volume Correction Factors, Part 1-Introduction
API MPMS 12.2.2: 2010	Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 2-Measurement Tickets
API MPMS 12.2.3: 2009	Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 3-Proving Reports
API MPMS 12.2.4: 2009	Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volume Correction Factors, Part 4-Calculation of Base Prover Volumes by Waterdraw Method
API MPMS 12.2.5: 2009	Calculation of Petroleum Quantities – Section 2 – Calculation Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 5 – Calculation of Base Prover Volume by Master Meter Method

API MPMS 21.2: 2004 Electronic Liquid Volume Measurement Using Positive Displacement and Turbine Meters

Abstract of standards

ISO 91-1:1992 “Petroleum measurement tables - Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F” refers to petroleum measurement tables published by the American Petroleum Institute (API, USA), the American Society for Testing and Materials (ASTM, USA) and the Institute of Petroleum (IP, UK) and subsidiary documents, correcting the printing errors in these publications, based on reference temperatures of 15 °C and 60 °F. The standard reference temperature for petroleum measurement adopted in IS0 5024 is 15 °C, and should be used for international trade. However, it is recognized that its use is not yet universally accepted and references to tables based on 60 °F have therefore been included in IS0 91-1:1992 and tables based on 20 °C are covered in IS0 91-2.

ISO 91-2:1991 “Petroleum measurement tables - Part 2: Tables based on a reference temperature of 20 degrees C” refers to computer implementation procedures for the correction of densities and volumes to the reference temperature of 20°C. This first edition cancels and replaces ISO/TR 91:1970/Add.1:1975. Annex A is for information only.

ISO 4267-2:1988 “Petroleum and liquid petroleum products - Calculation of oil quantities - Part 2: Dynamic measurement” defines the various terms employed in the calculation of metered petroleum quantities. Also specifies the equations which allow the values of correction factors to be computed. Also gives rules for the sequence, rounding and significant figures to be employed in a calculation. Provides tables which may be used to look up specific correction factors should it not be desired to calculate them by manual as well as computer methods. The field of application is the volumetric measurement of liquid hydrocarbons, including liquefied petroleum gases, by meter and prover. It does not include two-phase fluids.

ISO 9770:1989 “Crude petroleum and petroleum products -- Compressibility factors for hydrocarbons in the range 638 kg/m3 to 1 074 kg/m3” includes the contents of Manual of Petroleum Measurement Standards, Chapter 11.2.1M published August 1984 by API. The purpose is to correct hydrocarbon volumes metered under pressure to the corresponding volumes at the equilibrium pressure for the metered temperature. Contains compressibility factors related to meter temperature and density of metered material.

API MPMS 11.1: 2004 “Petroleum measurement tables - Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F” provides the algorithm and implementation procedure for the correction of temperature and pressure effects on density and volume of liquid hydrocarbons which fall within the categories of crude oil, refined products, or lubricating oils; NGLs and LPGs are excluded from consideration in this Standard. This document is distributed on CD-ROM in Portable Document Format (PDF). A utility program is included on the CD to allow users to calculate corrections for temperature and pressure effects and to print pages of correction factors for a user-defined range of temperature, pressure and density in both US Customary and Metric units of measure. The utility is used within a supported web browser and uses the Java language. Internet access is not required. (Printed tables are not available from either API or ASTM for this edition of Chapter 11.1 Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils.)

API MPMS 11.2.2:2007 "Compressibility Factors for Hydrocarbons: 0.350–0.637 Relative Density (60 °F/60 °F) and –50 °F to 140 °F Metering Temperature" provides tables to correct hydrocarbon volumes metered under pressure for the metered temperature. Contains compressibility factors related to the meter temperature and relative density (60 °F/60 °F) of the metered material.

API MPMS 11.2.2M:2007 "Compressibility Factors for Hydrocarbons: 350–637 Kilograms per Cubic Meter Density (15 °C) and –46 °C to 60 °C Metering Temperature" provides tables to correct hydrocarbon volumes metered under pressure to corresponding volumes at equilibrium pressure for the metered temperature. The standard contains compressibility factors related to the meter temperature and density (15 °C) of the metered material.

API MPMS 12.2.1:2009 "Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volume Correction Factors, Part 1-Introduction" provides the general introduction of this standard which is divided into five parts, each published separately. The base (reference or standard) volumetric determination of metered quantities is discussed along with the general terms required for solution of the various equations. General rules for rounding of numbers, including field data, intermediate calculations numbers, and discrimination levels are specified.

API MPMS 12.2.2:2010 "Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 2—Measurement Tickets" provides standardized calculation methods for the quantification of liquids and the determination of base prover volumes under defined conditions, regardless of the point of origin or destination or the units of measure required by governmental customs or statute. The publication rigorously specifies the equations for computing correction factors, rules for rounding, calculational sequence, and discrimination levels to be employed in the calculations.

API MPMS 12.2.3:2009 "Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 3-Proving Reports" consolidates and standardizes calculations for metering petroleum liquids using turbine or displacement meters and clarifies terms and expressions by eliminating local variations among terms. This standard provides calculation methods for the determination of meter factors under defined conditions, regardless of the point of origin or destination or units of measure required by governmental customs or statute. This document specifies the equations for computing correction factors, including the calculation sequence, discrimination levels, and rules for rounding.

API MPMS 12.2.4:2009 "Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volume Correction Factors, Part 4-Calculation of Base Prover Volumes by Waterdraw Method" provides a standardized calculation method to determine a base prover volume under defined conditions. Specifically, this standard discusses the calculation procedures for the waterdraw calibration method, which is one of several different procedures used to determine Base Prover Volume (BPV) of a displacement prover.

API MPMS 12.2.5: 2009 "Calculation of Petroleum Quantities – Section 2 – Calculation Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 5 – Calculation of Base Prover Volume by Master Meter Method'' specifies the equations for computing correction factors, rules for rounding, including the calculation sequence and discrimination levels to be employed in the calculations. No deviations from these specified equations are permitted, since the intent of this document is to establish a rigorous standard.

API MPMS 21.2: 2004 "Electronic Liquid Volume Measurement Using Positive Displacement and Turbine Meters" provides guidance for the effective use of electronic liquid measurement systems for custody transfer measurement of liquid hydrocarbons under the following conditions. Use of the measurement systems must fall within the scope and field of application of API MPMS Chapter 12.2. Guidance applies to systems using turbine or positive displacement meters. Guidance applies to systems using on-line CTL and CPL compensation. The procedures and techniques in MPMS Chapter 21.2 are recommended for new measurement applications. This standard provides custody transfer measurement procedures for pipeline and other electronic liquid metering systems including design, selection, use, auditing, reporting, calibration, verification and security

Other relevant Standards

ISO 4124: 1994	Liquid hydrocarbons - Dynamic measurement - Statistical control of volumetric metering systems
API MPMS 20.1: 2006	Allocation Measurement
OIML R 117-1: 2007	Dynamic measurement systems for liquids other than water

ISO 4124: 1994 "Liquid hydrocarbons -- Dynamic measurement -- Statistical control of volumetric metering systems". In dynamic measuring systems the performance of meters for liquid hydrocarbons will vary with changes in flow conditions, viz. flowrate, viscosity, temperature, pressure, density of product, and with mechanical wear. Has been prepared as a guide for establishing and monitoring the performance of such meters, using appropriate statistical control procedures for both central and on-line proving. These procedures may be applied to measurements made by any type of volumetric or mass metering systems. The procedures to be followed for collecting data, on which the control limits are based, are described.

API MPMS 20.1:2006 "Allocation Measurement" provides design and operating guidelines for liquid and gas allocation measurement systems. Included are recommendations for metering, static measurement, sampling, proving, calibrating and calculating procedures.

OIML R117-1:2007 specifies the metrological and technical requirements applicable to dynamic measuring systems for quantities (volume or mass) of liquids other than water subject to legal metrology controls. It also provides requirements for the approval of parts of the measuring systems (meter, etc.).

Gas Measurement Systems
General

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

All sections

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

All sections

Most Significant Standards

OIML Recommendation

R140:2007	Measuring systems for gaseous fuel
R137-1:2006	Gas meters – Part 1: Requirements
ISO 14532:2001	Natural Gas Vocabulary

Abstract of standard

OIML R140:2007 “Measuring systems for gaseous fuel” applies to measuring systems for gaseous fuel:

- with a designed maximum flowrate Qmax equal to or greater than 100 m3/h at base conditions and for operating pressures equal to or greater than 200 kPa (2 bar) absolute;
- not fitted with diaphragm gas meters.

It may apply to very large measuring systems located at the border between two countries as well as to smaller measuring systems, with the exception of measuring systems for compressed natural gas for vehicles (CNG). However, the provisions of this Recommendation may be adapted to other cases. This Recommendation lays down the metrological and technical requirements applicable to the measuring systems subject to legal metrology controls.

Different types of measuring systems are considered:

- measuring systems providing indications of volume at base conditions (as defined in this Recommendation) or mass converted from a volume of gas determined at metering or base conditions;
- measuring systems directly providing the mass of gas;
- measuring systems providing an indication of energy corresponding to a volume at base conditions or a mass of gas.

The concept of a measuring system may involve data and figures provided according to documented provisions. This is often necessary in particular for the determination of energy. In this case the purpose of this Recommendation is to provide tools in order to manage energy on a metrological basis (see examples in D.3). It is not intended to prohibit the use of other tools allowing the management of energy (see examples in D.4).

The conversion of mass to volume is not covered in the scope of this Recommendation; however, it is not intended to eliminate this possibility. In such a case appropriate provisions in this Recommendation have to be adapted. Annex G gives information on this type of conversion. This Recommendation also provides the way the measuring systems are approved and verified. The requirements for measuring systems are complementary to those applicable only to meters as provided in OIML R 137-1.

This Recommendation does not provide any requirements that are applicable to meters.

OIML R137-1:2006 "Gas meters – Part 1: Requirements" applies to gas meters based on any principle, used to meter the quantity of gas in volume, mass or energy units that has passed through the meter at operating conditions. It applies also to gas meters intended to measure quantities of gaseous fuels or other gases, except gases in the liquefied state and steam. Dispensers for compressed natural gas (CNG dispensers) are also excluded from the scope of this Recommendation. This Recommendation also applies to correction devices, and other electronic devices that can be attached to the gas meter. However, provisions for conversion devices, either as part of the gas meter or as a separate instrument, or provisions for devices for the determination of the superior calorific value and gas metering systems consisting of several components, are defined in the draft OIML Recommendation on Measuring systems for gaseous fuel.

ISO 14532:2001 ''Natural Gas Vocabulary'' establishes the terms, definitions, symbols and abbreviations used in the field of natural gas. The terms and definitions have been reviewed and studied in order to cover all aspects of any particular term with input from other sources such as European standards from CEN (The European Committee for standardization), national standards and existing definitions in the IGU dictionary of the gas industry.

Other relevant Standards

NS-EN 1776: 1999 Gas supply systems - Natural gas measuring stations – Functional requirements

NS-EN 1776:1999 "Gas supply systems - Natural gas measuring stations – Functional requirements" This European standard specifies functional requirements for the design, construction, commissioning, operation and maintenance of new gas measuring stations for non-domestic custody transfer of natural gas as described in ISO 13686 with a design capacity equal to or greater than 500 m3/h (at base conditions, see 4.1) and for operating pressures equal to or greater than 1 bar (gauge pressure). NOTE: Installations using diaphragm gas meters as primary measuring instruments are not covered by this standard. Except for safety and environmental aspects, the extent to which the requirements of this standard are applied should be justified by the economics of the measuring station. Therefore, stations with an annual throughput of equal to or smaller than 300 000 m^3 (at base conditions) are excluded from the scope of this standard. This European Standard specifies common basic principles for gas supply systems. Users of this European Standard should be aware that more detailed national standards and/or codes of practice may exist in the CEN member countries. This European Standard is intended to be applied in association with these national standards and/or codes of practice setting out the above mentioned basic principles.

Gas Measurement Systems
Differential Pressure Meters

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 14: The mechanical part of the metering system
Section 25: Operating requirements for flow meters

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements - General
Section 5.1.7.2: Sales and allocation measurement - Functional requirements - Maintenance requirements – Calibration
Section 5.2.3.5: Sales and allocation measurement - Technical requirements – Instrument part - Stability for smart transmitters
Section 5.2.3.11: Sales and allocation measurement - Technical requirements - Instrument part – Differential pressure transmitter
Section 5.2.3.15: Sales and allocation measurement - Technical requirements - Instrument part - Instrument tubing
Section 5.2.3.16: Sales and allocation measurement - Technical requirements - Instrument part – Enclosures
Section 5.2.4.5: Sales and allocation measurement - Technical requirements - Computer part – Calculations
Section 6.2.3.9: Fuel gas measurement - Technical requirements - Instrument part - Differential pressure transmitter
Section 7.1.3: Flare gas measurement - Functional requirements - Equipment/schematic
Annex A: (Normative) Requirements for automated condition based maintenance

Most Significant Standards

ISO Standards

ISO 5167-1: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 1: General principles and requirements
ISO 5167-2: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 2: Orifice plates
ISO 5167-3: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 3: Nozzles and Venturi nozzles

ISO 5167-4: 2003 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 4: Venturi tubes

Abstract of standard

ISO 5167-1:2003 "Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 1: General principles and requirements" defines terms and symbols and establishes the general principles for methods of measurement and computation of the flowrate of fluid flowing in a conduit by means of pressure differential devices (orifice plates, nozzles and Venturi tubes) when they are inserted into a circular cross-section conduit running full. ISO 5167-1:2003 also specifies the general requirements for methods of measurement, installation and determination of the uncertainty of the measurement of flowrate. It also defines the general specified limits of pipe size and Reynolds number for which these pressure differential devices are to be used. ISO 5167 (all parts) is applicable only to flow that remains subsonic throughout the measuring section and where the fluid can be considered as single-phase. It is not applicable to the measurement of pulsating flow.

ISO 5167-2:2003 "Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 2: Orifice plates" specifies the geometry and method of use (installation and operating conditions) of orifice plates when they are inserted in a conduit running full to determine the flow-rate of the fluid flowing in the conduit. It also provides background information for calculating the flow-rate and is applicable in conjunction with the requirements given in ISO 5167-1. ISO 5167-2:2003 is applicable to primary devices having an orifice plate used with flange pressure tappings, or with corner pressure tappings, or with D and D/2 pressure tappings. Other pressure tappings such as vena contracta and pipe tappings have been used with orifice plates but are not covered by ISO 5167-2:2003. ISO 5167-2:2003 is applicable only to a flow which remains subsonic throughout the measuring section and where the fluid can be considered as single phase. It is not applicable to the measurement of pulsating flow. It does not cover the use of orifice plates in pipe sizes less than 50 mm or more than 1 000 mm, or for pipe Reynolds numbers below 5000.

ISO 5167-3:2003 "Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 3: Nozzles and Venturi nozzles" specifies the geometry and method of use (installation and operating conditions) of nozzles and Venturi nozzles when they are inserted in a conduit running full to determine the flow-rate of the fluid flowing in the conduit. ISO 5167-3:2003 also provides background information for calculating the flow-rate and is applicable in conjunction with the requirements given in ISO 5167-1. ISO 5167-3:2003 is applicable to nozzles and Venturi nozzles in which the flow remains subsonic throughout the measuring section and where the fluid can be considered as single-phase. In addition, each of the devices can only be used within specified limits of pipe size and Reynolds number. It is not applicable to the measurement of pulsating flow. It does not cover the use of nozzles and Venturi nozzles in pipe sizes less than 50 mm or more than 630 mm, or for pipe Reynolds numbers below 10 000. ISO 5167-3:2003 deals with two types of standard nozzles, the ISA 1932 nozzle and the long radius nozzle, as well as the Venturi nozzle.

The two types of standard nozzle are fundamentally different and are described separately in ISO 5167-3:2003. The Venturi nozzle has the same upstream face as the ISA 1932 nozzle, but has a divergent section and, therefore, a different location for the downstream pressure tappings, and is described separately. This design has a lower pressure loss than a similar nozzle. For both of these nozzles and for the Venturi nozzle direct calibration experiments have been made, sufficient in number, spread and quality to enable coherent systems of application to be based on their results and coefficients to be given with certain predictable limits of uncertainty.

ISO 5167-4:2003 "Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 4: Venturi tubes" specifies the geometry and method of use (installation and operating conditions) of Venturi tubes when they are inserted in a conduit running full to determine the flowrate of the fluid flowing in the conduit. ISO 5167-4:2003 also provides background information for calculating the flow-rate and is applicable in conjunction with the requirements given in ISO 5167-1. ISO 5167-4:2003 is applicable only to Venturi tubes in which the flow remains subsonic throughout the measuring section and where the fluid can be considered as single-phase. In addition, each of these devices can only be used within specified limits of pipe size, roughness, diameter ratio and Reynolds number. ISO 5167-4:2003 is not applicable to the measurement of pulsating flow. It does not cover the use of Venturi tubes in pipes sized less than 50 mm or more than 1 200 mm, or for where the pipe Reynolds numbers are below 20 000. ISO 5167-4:2003 deals with the three types of classical Venturi tubes: cast, machined and rough welded sheet-iron. A Venturi tube is a device which consists of a convergent inlet connected to a cylindrical throat which is in turn connected to a conical expanding section called the "divergent". The differences between the values of the uncertainty of the discharge coefficient for the three types of classical Venturi tube show, on the one hand, the number of results available for each type of classical Venturi tube and, on the other hand, the more or less precise definition of the geometric profile. The values are based on data collected many years ago. Venturi nozzles (and other nozzles) are dealt with in ISO 5167-3.

Other relevant Standards

ISO/TR 9464: 2008	Guidelines for the use of ISO 5167:2003
ISO/TR 12767: 2007	Measurement of fluid flow by means of pressure differential devices -- Guidelines on the effect of departure from the specifications and operating conditions given in ISO 5167
ISO/TR 15377: 2007	Measurement of fluid flow by means of pressure-differential devices -- Guidelines for the specification of orifice plates, nozzles and Venturi tubes beyond the scope of ISO 5167
ISO 9300: 2005	Measurement of gas flow by means of critical flow Venturi nozzles
AGA Report Nr 3-1: 2009 **API MPMS 14.3.1**	Orifice Metering of Natural Gas Part 1: General Equations & Uncertainty Guidelines
AGA Report Nr 3-2: 2006 **API MPMS 14.3.2**	Orifice Metering of Natural Gas Part 2: Specification and Installation Requirements
AGA Report Nr 3-3: 2009 **API MPMS 14.3.3**	Orifice Metering of Natural Gas Part 3: Natural Gas Applications
AGA Report Nr 3-4: 2006 **API MPMS 14.3.4**	Orifice Metering of Natural Gas Part 4: Background, Development Implementation Procedure

ISO/TR 9464:2008 “Guidelines for the use of ISO 5167:2003” provides guidance on the use of ISO 5167:2003 (all parts). ISO 5167:2003 is an International Standard for flow measurement based on the differential pressure generated by a constriction introduced into a circular conduit. It presents a set of rules and requirements based on theory and experimental work undertaken in the field of flow measurement

ISO/TR 12767:2007 “Measurement of fluid flow by means of pressure differential devices -- Guidelines on the effect of departure from the specifications and operating conditions given in ISO 5167” provides guidance on estimating the flowrate when using pressure differential devices constructed or operated outside the scope of ISO 5167. Additional tolerances or corrections cannot necessarily compensate for the effects of deviating from ISO 5167 (all parts). The information is given, in the first place, to indicate the degree of care necessary in the manufacture, installation and maintenance of pressure differential devices by describing some of the effects of non-conformity to the requirements; and in the second place, to permit those users who cannot comply fully with the requirements to assess, however roughly, the magnitude and direction of the resulting error in flowrate. Each variation dealt with is treated as though it were the only one present. Where more than one is known to exist, there may be unpredictable interactions and care has to be taken when combining the assessment of these errors. If there is a significant number of errors, means of eliminating some of them have to be considered. The variations included in ISO/TR 12767 are by no means complete and relate largely to examples with orifice plates. An example with Venturi tubes has been placed at the end of its section. There are, no doubt, many similar examples of installations not conforming to ISO 5167 (all parts) for which no comparable data have been published. Such additional information from users, manufacturers and any others may be taken into account in future revisions of ISO/TR 12767.

ISO/TR 15377:2007 “Measurement of fluid flow by means of pressure-differential devices -- Guidelines for the specification of orifice plates, nozzles and Venturi tubes beyond the scope of ISO 5167” describes the geometry and method of use for conical-entrance orifice plates, quarter-circle orifice plates, eccentric orifice plates and Venturi tubes with 10,5 degree convergent angles. Recommendations are also given for square-edged orifice plates and nozzles under conditions outside the scope of ISO 5167.

ISO 9300:2005 “Measurement of gas flow by means of critical flow Venturi nozzles” specifies the geometry and method of use (installation in a system and operating conditions) of critical flow Venturi nozzles (CFVN) used to determine the mass flow-rate of a gas flowing through a system. It also gives the information necessary for calculating the flow-rate and its associated uncertainty. It is applicable to Venturi nozzles in which the gas flow accelerates to the critical velocity at the throat (this being equal to the local sonic velocity), and only where there is steady flow of single-phase gases.

AGA Report Nr 3-1: 2003 “Orifice Metering of Natural Gas Part 1: General Equations & Uncertainty Guidelines” provides the basic equations and uncertainty statements for computing the flow through orifice meters. In Part 1, the traditional basic orifice factor and Reynolds number factor found in the 1985 edition have been replaced with a more fundamental coefficient of discharge that is a function of line size, beta radio, and pipe Reynolds number. The upstream expansion factor is not changed from the 1985 edition. The downstream expansion factor has been reanalyzed to include compressibility. Although each part of the document can be used

independently for many applications, users with natural gas applications should review Parts 3 and 4 before implementing Part 1.

AGA Report Nr 3-2: 2006 “Orifice Metering of Natural Gas Part 2: Specification and Installation Requirements” outlines the specification and installation requirements for the measurement of single-phase, homogeneous Newtonian fluids using concentric, square-edged, flange-tapped orifice meters. It provides specifications for the construction and installation of orifice plates, meter tubes, and associated fittings when designing metering facilities using orifice meters.

AGA Report Nr 3-3: 2009 “Orifice Metering of Natural Gas Part 3: Natural Gas Applications” developed as an application guide for the calculation of natural gas flow through a flange-tapped, concentric orifice meter, using the inch-pound system of units. It also provides practical guidelines for applying Chapter 14.3, Parts 1 and 2, to the measurement of natural gas.

AGA Report Nr 3-4: 2006 “Orifice Metering of Natural Gas Part 4: Background, Development Implementation Procedure” describes the background and development of the equation for the coefficient of discharge of flange-tapped square-edged concentric orifice meters and recommends a flow rate calculation procedure. The recommended procedures provide consistent computational results for the quantification of fluid flow under defined conditions, regardless of the point of origin or destination, or the units of measure required by governmental customs or statute. The procedures allow different users with different computer languages on different computing hardware to arrive at almost identical results using the same standardized input data.

Gas Measurement Systems
Ultrasonic Meters

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 25: Operating requirements for flow meters

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 5.1.8: Sales and allocation measurement - Functional requirements - Layout requirements
Section 5.2.2.3: Sales and allocation measurement - Technical requirements - Mechanical part - Meter runs and header design
Section 5.2.2.4: Sales and allocation measurement - Technical requirements - Mechanical part - Flow meter designs
Section 5.2.3.2: Sales and allocation measurement - Technical requirements - Instrument part - Location of sensors
Section 5.2.3.10: Sales and allocation measurement - Technical requirements - Instrument part - Ultrasonic flow meter
Section 5.2.4.6: Sales and allocation measurement - Technical requirements - Computer part - Check
Section 6.1.3: Fuel gas measurement - Functional requirements - Equipment/schematic
Section 6.1.8: Fuel gas measurement - Functional requirements - Layout requirements
Section 6.1.11: Fuel gas measurement - Functional requirements - Special consideration for fuel gas system
Section 6.2.2.4: Fuel gas measurement - Technical requirements - Mechanical part - Flow meter designs
Section 6.2.3.8: Fuel gas measurement - Technical requirements - Instrument part - Ultrasonic flow meter
Section 7.1.3: Flare gas measurement - Functional requirements - Equipment/schematic
Section 7.1.10: Flare gas measurement - Functional requirements - Testing and commissioning requirements
Section 7.2.1: Flare gas measurement - Technical requirements - Mechanical part
Section 9.1.4.2: Gas chromatograph - Functional requirements – Performance - Availability and reliability
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning

Most Significant Standards

ISO Standards

ISO 17089-1: 2010	Measurement of fluid flow in closed conduits - Ultrasonic meters for gas - Part 1: Meters for custody transfer and allocation measurement
ISO/DIS 17089-2 (1)	Measurement of fluid flow in closed conduits - Ultrasonic meters for gas -- Part 2: Meters for industrial applications

(1): Not published at time of edition.

AGA Standards

AGA Report Nr 9: 2007	Measurement of Gas by Multipath Ultrasonic Meters
AGA Report Nr 10: 2003	Speed of Sound in Natural Gas and Other Related Hydrocarbon Gases

Abstract of standard

ISO 17089-1:2010 “Measurement of fluid flow in closed conduits - Ultrasonic meters for gas - Part 1: Meters for custody transfer and allocation measurement” specifies requirements and recommendations for ultrasonic gas flowmeters (USMs), which utilize the transit time of acoustic signals to measure the flow of single phase homogenous gases in closed conduits. ISO 17089-1:2010 applies to transit time ultrasonic gas flowmeters used for custody transfer and allocation metering, such as full-bore, reduced-area, high-pressure, and low-pressure meters or any combination of these. There are no limits on the minimum or maximum sizes of the meter. ISO 17089-1:2010 can be applied to the measurement of almost any type of gas, such as air, natural gas, and ethane. Included are flow measurement performance requirements for meters of two accuracy classes suitable for applications such as custody transfer and allocation measurement. ISO 17089-1:2010 specifies construction, performance, calibration, and output characteristics of ultrasonic meters for gas flow measurement and deals with installation conditions.

AGA Report Nr 9:2007 “Measurement of Gas by Multipath Ultrasonic Meters”. This report is for multipath ultrasonic transit-time flow meters, typically 6" and larger in diameter, used for the measurement of natural gas. It is written in the form of a performance-based specification.

AGA Report Nr 10:2005 “Natural gas -- Calculation of thermodynamic properties -- Part 1: Gas phase properties for transmission and distribution applications”. This report outlines a method for the calculation of the speed of sound in natural gas and the individual components that make up natural gas. It also calculates the entropy, enthalpy and C* coefficient for sonic nozzles. It also provides computer codes for programming calculations of speed of sound.

Other relevant Standards

ISO 20765-1: 2005	Natural gas -- Calculation of thermodynamic properties -- Part 1: Gas phase properties for transmission and distribution applications

ISO 20765-1:2005 “Natural gas -- Calculation of thermodynamic properties -- Part 1: Gas phase properties for transmission and distribution applications”. This part of ISO 20765 specifies a method of calculation for the volumetric and caloric properties of natural gases, natural gases containing synthetic admixture and similar mixtures, at conditions where the mixture can exist only as a gas. The method is applicable to pipeline-quality gases within the ranges of pressure and temperature at which transmission and distribution operations normally take place. For volumetric properties (compression factor and density), the uncertainty of calculation is about ± 0,1 % (95 % confidence interval). For caloric properties (for example enthalpy, heat capacity, Joule-Thomson coefficient, speed of sound), the uncertainty of calculation is usually greater.

Gas Measurement Systems
Coriolis Meters

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 25: Operating requirements for flow meters

NORSOK References

NORSOK Standard I-104: 2005 "Fiscal measurement systems for hydrocarbon gas"

Section 5.2.2.3: Sales and allocation measurement - Technical requirements - Mechanical part - Meter runs and header design.
Section 5.2.2.4: Sales and allocation measurement - Technical requirements - Mechanical part - Flow meter designs.

Most Significant Standards

ISO Standards

ISO 10790:1999	Measurement of fluid flow in closed conduits -- Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)
ISO 10790:1999/Amd 1:2003	Guidelines for gas measurement

AGA Standards

AGA Report Nr 11: 2003	Measurement of Natural Gas by Coriolis Meter

Abstract of standard

ISO 10790:1999 "Measurement of fluid flow in closed conduits -- Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)" gives guidelines for selection, installation, calibration, performance and operation of Coriolis meters for determination of mass flow, density, volume flow and other related parameters of fluids. The standard primarily concentrates on measurement of liquids. Amendment 1 (2003) extend the standard to cover some aspects of gas measurement with Coriolis meters.

AGA Report Nr 11:2003 “Measurement of Natural Gas by Coriolis Meter” provides a performance-based specification and test methods for Coriolis meters intended to use for flow measurement of natural gas. It contains several appendices addressing such issues as theory, operation, accuracy, research, test data, etc.

Gas Measurement Systems
Turbine Meters

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 6.1.3: Fuel gas measurement - Functional requirements - Equipment/schematic
Section 6.1.11: Fuel gas measurement - Functional requirements - Special consideration for fuel gas system.
Section 6.2.2.4: Fuel gas measurement - Technical requirements- Mechanical part - Flow meter designs.
Section 6.2.4.7: Fuel gas measurement - Technical requirements - Computer part - Error handling.
Annex B: (Normative) Testing and commissioning

Most Significant Standards

ISO Standards

ISO 9951:1993	Measurement of gas flow in closed conduits -- Turbine meters
ISO 9951:1993/Cor 1:1994	Measurement of gas flow in closed conduits -- Turbine meters

AGA Standards

AGA Report Nr 7: 2006	Measurement of Natural Gas by Turbine Meter

Abstract of standard

ISO 9951:1993 “Measurement of gas flow in closed conduits -- Turbine meters” specifies dimensions, ranges, construction, performance, calibration and output characteristics of the turbine meters. Also deals with installation conditions, leakage testing und pressure testing and provides a series of informative annexes A to E including recommendations for use, field checks, and perturbations of the fluid flowing. In many countries, some or all of the items covered are subject to mandatory regulations imposed by the laws of these countries. Where conflicts exist, the mandatory regulations shall prevail.

AGA Report Nr 7:2006 “Measurement of Natural Gas by Turbine Meter” provides information on the theory of operation, performance characteristics, and installation and maintenance of turbine meters. Also includes technique for flow computation, calibration and field checks.

Other relevant Standards

ISO 6551: 1982	Petroleum liquids and gases -- Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data

ISO 6551: 1982 “Petroleum liquids and gases - Fidelity and security of dynamic measurement - Cabled transmission of electric and/or electronic pulsed data” establishes guidelines for ensuring the quantities stated, a main objective being to ensure the integrity of the primary indication. In order to achieve different levels of security, criteria and recommendations for the design, installation, use and maintenance of the relevant equipment are laid down. Regulatory requirements, including those for safety, are not specifically covered in detail but certain general cautionary notes on safety are included for guidance.

Gas Measurement Systems
Pressure and Temperature Instruments

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 10: Reference conditions
Section 13: Requirements to the metering system in general
Section 15: The instrument part of metering system
Section 25: Operational requirement for flow meters

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements – General
Section 5.1.7.2: Sales and allocation measurement - Functional requirements - Maintenance requirements - Calibration
Section 5.1.8: Sales and allocation measurement - Functional requirements – Layout requirements
Section 5.2.2.2: Sales and allocation measurement – Technical requirements - Mechanical part – Meter run pressure setting/equalizing
Section 5.2.2.7: Sales and allocation measurement – Technical requirements - Mechanical part – Thermal insulation
Section 5.2.3.1: Sales and allocation measurement – Technical requirements – Instrument part – General
Section 5.2.3.2: Sales and allocation measurement – Technical requirements – Instrument part – Location of sensors
Section 5.2.3.5: Sales and allocation measurement – Technical requirements – Instrument part – Stability for smart transmitters
Section 5.2.3.6: Sales and allocation measurement – Technical requirements – Instrument part – Temperature loop
Section 5.2.3.7: Sales and allocation measurement – Technical requirements – Instrument part – Thermowells
Section 5.2.3.8: Sales and allocation measurement – Technical requirements – Instrument part – Direct density measurement
Section 5.2.3.11: Sales and allocation measurement – Technical requirements – Instrument part – Differential pressure transmitter
Section 5.2.3.13: Sales and allocation measurement – Technical requirements – Instrument part – Local pressure indication
Section 5.2.3.15: Sales and allocation measurement – Technical requirements – Instrument part – Instrument tubing
Section 5.2.3.16: Sales and allocation measurement – Technical requirements – Instrument part – Enclosures

Section 5.2.4.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Section 5.2.4.5: Sales and allocation measurement – Technical requirements – Computer part – Calculations
Section 6.1.8: Fuel gas measurement – Functional requirements – Layout requirements
Section 6.2.2.2: Fuel gas measurement – Technical requirements – Mechanical part - Meter run pressure setting/equalizing
Section 6.2.3.5: Fuel gas measurement – Technical requirements – Instrument part - Temperature loop
Section 6.2.3.6: Fuel gas measurement – Technical requirements – Instrument part - Thermowells
Section 6.2.3.9: Fuel gas measurement – Technical requirements – Instrument part - Differential pressure transmitter
Section 6.2.3.11: Fuel gas measurement – Technical requirements – Instrument part - Local pressure indication
Section 7.1.3: Flare gas measurement – Functional requirements – Equipment/schematic
Section 7.1.6: Flare gas measurement – Functional requirements – Operational requirements
Section 7.2.1: Flare gas measurement – Technical requirements – Mechanical part
Section 7.2.2: Flare gas measurement – Technical requirements – Instrument part
Section 8.1.3: Gas samplers systems – Functional requirements – Equipment/schematic
Section 8.2.6: Gas samplers systems – Technical requirements – Sample receiver
Section 8.2.7: Gas samplers systems – Technical requirements – Tubing and valves
Section 8.2.8: Gas samplers systems – Technical requirements – Back-pressure system
Section 9.1.4.1: Gas chromatograph – Functional requirements – Performance - Uncertainty
Section 9.1.5: Gas chromatograph – Functional requirements – Process/ambient conditions
Section 9.2.1: Gas chromatograph – Technical requirements – Sample handling system
Section 9.2.2: Gas chromatograph – Technical requirements – Analytical unit

Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning
Annex D (Informative) Example of performance calculation of online gas chromatograph (OGC) result

Most Significant Standards

ISO Standard

ISO 15970: 2008	Natural gas -- Measurement of properties -- Volumetric properties: density, pressure, temperature and compression factor
CEI 60751: 2008	Industrial platinum resistance thermometers and platinum temperature sensors

Abstract of standards

ISO 15970:2008 “Natural gas -- Measurement of properties -- Volumetric properties: density, pressure, temperature and compression factor” gives requirements and procedures for the measurement of the properties of natural gas that are used mainly for volume calculation and volume conversion: density at reference and at operating conditions, pressure, temperature and compression factor.

Only those methods and instruments are considered that are suitable for field operation under the conditions of natural gas transmission and distribution, installed either in-line or on-line, and that do not involve the determination of the gas composition. ISO 15970:2008 gives examples for currently used instruments that are available commercially and of interest to the natural gas industry. The density at reference conditions (sometimes referred to as normal, standard or even base density) is required for conversion of volume data and can be used for other physical properties. Density at operating conditions is measured for mass-flow measurement and volume conversion using the observed line density and can be used for other physical properties. ISO 15970:2008 covers density transducers based on vibrating elements, normally suitable for measuring ranges of 5 kg/m^3 to 250 kg/m^3. Pressure measurement deals with differential, gauge and absolute pressure transmitters. It considers both analogue and smart transmitters (i.e. microprocessor based instruments) and, if not specified otherwise, the corresponding paragraphs refer to differential, absolute and gauge pressure transmitters without distinction. Temperature measurements in natural gas are performed within the range of conditions under which transmission and distribution are normally carried out (253 K < T < 338 K). In this field of application, resistance thermometer detectors (RTD) are generally used. The compression factor (also known as the compressibility factor or the real gas factor and given the symbol Z) appears, in particular, in equations governing volumetric metering. Moreover, the conversion of volume at metering conditions to volume at defined reference conditions can properly proceed with an accurate knowledge of Z at both relevant pressure and relevant temperature conditions.

CEI 60751:2008 “Industrial platinum resistance thermometers and platinum temperature sensors” specifies the requirements and temperature/resistance relationship for industrial platinum resistance temperature sensors later referred to as “platinum resistors” or "resistors" and industrial platinum resistance thermometers later referred to as "thermometers" whose electrical resistance is a defined function of temperature.

Other relevant Standards

Gas Measurement Systems

Differential Pressure and Temperature Instruments

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements – General
Section 5.1.7.2: Sales and allocation measurement - Functional requirements - Maintenance requirements - Calibration
Section 5.2.3.5: Sales and allocation measurement – Technical requirements – Instrument part – Stability for smart transmitters
Section 5.2.3.11: Sales and allocation measurement – Technical requirements – Instrument part – Differential pressure transmitter
Section 5.2.3.15: Sales and allocation measurement – Technical requirements – Instrument part – Instrument tubing
Section 5.2.3.16: Sales and allocation measurement – Technical requirements – Instrument part – Enclosures
Annex A: (Normative) Requirements for automated condition based maintenance

Most Significant Standards

Other relevant Standards

ISO 5167-1: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 1: General principles and requirements
ISO 5167-2: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 2: Orifice plates
ISO 5167-3: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 3: Nozzles and Venturi nozzles
ISO 5167-4: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 4: Venturi tubes
ISO 2186:2007	Measurement of fluid flow in closed conduits -- Connections for pressure signal transmissions between primary and secondary elements.

Gas Measurement Systems

Density

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 15: The instrument part of the metering system
Section 25: Operating requirements for flow meters
Section 26: Operating requirements for instrument part

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 5.2.2.7: Sales and allocation measurement – Technical requirements - Mechanical part – Thermal insulation
Section 5.2.3.1: Sales and allocation measurement – Technical requirements – Instrument part – General
Section 5.2.3.2: Sales and allocation measurement – Technical requirements – Instrument part – Location of sensors
Section 5.2.3.8: Sales and allocation measurement – Technical requirements – Instrument part – Direct density measurement
Section 5.2.3.9: Sales and allocation measurement – Technical requirements – Instrument part – Calculated density
Section 5.2.4.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Section 5.2.4.5: Sales and allocation measurement – Technical requirements – Computer part – Calculations
Section 5.2.4.6: Sales and allocation measurement – Technical requirements – Computer part – Check
Section 6.2.3.7: Fuel gas measurement – Technical requirements – Instrument part - Density
Section 9.1.1: Gas chromatograph – Functional requirements – Performance - General
Section 9.1.4.1: Gas chromatograph – Functional requirements – Performance - Uncertainty
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning
Annex D (Informative) Example of performance calculation of online gas chromatograph (OGC) result

Most Significant Standards

ISO Standards

ISO 6976: 1995	Natural gas -- Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 6976:1995/Cor 2:1997	Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition

ISO 6976:1995/Cor 3:1999	Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 12213-1: 2006	Natural gas -- Calculation of compression factor -- Part 1: Introduction and guidelines
ISO 12213-2: 2006	Natural gas -- Calculation of compression factor -- Part 2: Calculation using molar-composition analysis
ISO 12213-3: 2006	Natural gas -- Calculation of compression factor -- Part 3: Calculation using physical properties
ISO 15970: 2008	Natural gas - Measurement of properties -- Volumetric properties: density, pressure, temperature and compression factor
ISO 20765-1: 2005	Natural gas - Calculation of thermodynamic properties - Part 1: Gas phase properties for transmission and distribution applications.

AGA Standards

AGA Report Nr 8: 1994	Compressibility Factor of Natural Gas and Related Hydrocarbon Gases

Abstract of standard

ISO 6976:1995 “Natural gas -- Calculation of calorific values, density, relative density and Wobbe index from composition” Specifies methods for the calculation of the superior calorific value and the inferior calorific value, density, relative density and Wobbe index of dry natural gas and other combustible gaseous fuels, when the composition of the gas by mole fraction is known. Replaces the first edition, which has been technically revised.

ISO 12213-1: 2006 “Natural gas -- Calculation of compression factor -- Part 1: Introduction and guidelines” specifies methods for the calculation of compression factors of natural gases, natural gases containing a synthetic admixture and similar mixtures at conditions under which the mixture can exist only as a gas. It is divided into three parts: this part, ISO 12213-1:2006, gives an introduction and provides guidelines for the methods of calculation described in Parts 2 and 3.

ISO 12213-2: 2006 “Natural gas -- Calculation of compression factor -- Part 2: Calculation using molar-composition analysis” specifies methods for the calculation of compression factors of natural gases, natural gases containing a synthetic admixture and similar mixtures at conditions under which the mixture can exist only as a gas. It is divided into three parts: this part, ISO 12213-2:2006, specifies a method for the calculation of compression factors when the detailed composition of the gas by mole fractions is known, together with the relevant pressures and temperatures. The method is applicable to pipeline quality gases within the ranges of pressure p and temperature T at which transmission and distribution operations normally take place, with an uncertainty of about +/- 0,1 %. It can be applied, with greater uncertainty, to wider ranges of gas composition, pressure and temperature.

ISO 12213-3: 2006 “Natural gas -- Calculation of compression factor -- Part 3: Calculation using physical properties” specifies methods for the calculation of compression factors of natural gases, natural gases containing a synthetic admixture and similar mixtures at conditions under which the mixture can exist only as a gas. It is divided into three parts: this part, ISO 12213-3:2006, specifies a method for the calculation of compression factors when the superior calorific value,

relative density and carbon dioxide content are known, together with the relevant pressures and temperatures. If hydrogen is present, as is often the case for gases with a synthetic admixture, the hydrogen content also needs to be known. The method is primarily applicable to pipeline quality gases within the ranges of pressure p and temperature T at which transmission and distribution operations normally take place, with an uncertainty of about +/-0,1 %. For wider-ranging applications the uncertainty of the results increases.

ISO 15970: 2008 "Natural gas -- Measurement of properties -- Volumetric properties: density, pressure, temperature and compression factor" gives requirements and procedures for the measurement of the properties of natural gas that are used mainly for volume calculation and volume conversion: density at reference and at operating conditions, pressure, temperature and compression factor. Only those methods and instruments are considered that are suitable for field operation under the conditions of natural gas transmission and distribution, installed either in-line or on-line, and that do not involve the determination of the gas composition. ISO 15970:2008 gives examples for currently used instruments that are available commercially and of interest to the natural gas industry. The density at reference conditions (sometimes referred to as normal, standard or even base density) is required for conversion of volume data and can be used for other physical properties. Density at operating conditions is measured for mass-flow measurement and volume conversion using the observed line density and can be used for other physical properties. ISO 15970:2008 covers density transducers based on vibrating elements, normally suitable for measuring ranges of 5 kg/m^3 to 250 kg/m^3. Pressure measurement deals with differential, gauge and absolute pressure transmitters. It considers both analogue and smart transmitters (i.e. microprocessor based instruments) and, if not specified otherwise, the corresponding paragraphs refer to differential, absolute and gauge pressure transmitters without distinction. Temperature measurements in natural gas are performed within the range of conditions under which transmission and distribution are normally carried out ($253\ K < T < 338\ K$). In this field of application, resistance thermometer detectors (RTD) are generally used. The compression factor (also known as the compressibility factor or the real gas factor and given the symbol Z) appears, in particular, in equations governing volumetric metering. Moreover, the conversion of volume at metering conditions to volume at defined reference conditions can properly proceed with an accurate knowledge of Z at both relevant pressure and relevant temperature conditions.

ISO 20765-1:2005 "Natural gas - Calculation of thermodynamic properties - Part 1: Gas phase properties for transmission and distribution applications" specifies a method of calculation for the volumetric and caloric properties of natural gases, natural gases containing synthetic admixture and similar mixtures, at conditions where the mixture can exist only as a gas. The method is applicable to pipeline-quality gases within the ranges of pressure and temperature at which transmission and distribution operations normally take place. For volumetric properties (compression factor and density), the uncertainty of calculation is about ± 0,1 % (95 % confidence interval). For caloric properties (for example enthalpy, heat capacity, Joule-Thomson coefficient, speed of sound), the uncertainty of calculation is usually greater.

AGA Report Nr 8:1994 "Compressibility Factor of Natural Gas and Related Hydrocarbon Gases" presents information needed (including efficient FORTRAN 77 computer program listings) to compute gas phase densities, and compressibility and super compressibility factors for natural gas and other related hydrocarbon gases.

Gas Measurement Systems
Energy (Calorific Value)

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measurement uncertainty
Section 11: Determination of energy content etc.
Section 25: Operating requirements for flow meters
Section 26: Operating requirements for instrument part

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements – General
Section 4.2: General requirements – Uncertainty
Section 5.2.4.5: Sales and allocation measurement – Technical requirements – Computer part – Calculations
Section 9.1.1: Gas chromatograph – Functional requirements – General
Section 9.1.4.1: Gas chromatograph – Functional requirements – Performance - Uncertainty
Annex B: (Normative) Testing and commissioning
Annex D (Informative) Example of performance calculation of online gas chromatograph (OGC) result

Most Significant Standards

ISO Standards

ISO 6976: 1995	Natural gas -- Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 6976:1995/Cor 2:1997	Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 6976:1995/Cor 3:1999	Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 15971: 2008	Natural gas -- Measurement of properties -- Calorific value and Wobbe index
ISO 15112: 2011	Natural gas -- Energy determination

AGA Standards

AGA Report Nr 5: 2009	Natural Gas Energy Measurement

Abstract of standard

ISO 6976:1995 “Natural gas -- Calculation of calorific values, density, relative density and Wobbe index from composition” Specifies methods for the calculation of the superior calorific value and the inferior calorific value, density, relative density and Wobbe index of dry natural gas and other combustible gaseous fuels, when the composition of the gas by mole fraction is known. Replaces the first edition, which has been technically revised.

ISO 15971:2008 “Natural gas -- Measurement of properties -- Calorific value and Wobbe index” concerns the measurement of calorific value of natural gas and natural gas substitutes by non-separative methods, i.e. methods that do not involve the determination of the gas composition, nor calculations from it. ISO 15971:2008 describes the principles of operation of a variety of instruments in use for this purpose, and provides guidelines for the selection, evaluation, performance assessment, installation and operation of these. Calorific values can be expressed on a mass basis, a molar basis or, more commonly, a volume basis. The working range for superior calorific value of natural gas, on the volume basis, is usually between 30 MJ/m^3 and 45 MJ/m^3 at standard reference conditions (see ISO 13443). The corresponding range for the Wobbe index is usually between 40 MJ/m^3 and 60 MJ/m^3. ISO 15971:2008 neither endorses nor disputes the claims of any commercial manufacturer for the performance of an instrument. Its central thesis is that fitness-for-purpose in any particular application (defined in terms of a set of specific operational requirements) can be assessed only by means of a well-designed programme of experimental tests. Guidelines are provided for the proper content of these tests.

ISO 15112: 2011 “Natural gas -- Energy determination” provides the means for energy determination of natural gas by measurement or by calculation, and describes the related techniques and measures that are necessary to take. The calculation of thermal energy is based on the separate measurement of the quantity, either by mass or by volume, of gas transferred and its measured or calculated calorific value. The general means of calculating uncertainties are also given. Only systems currently in use are described. ISO 15112:2011 applies to any gas-measuring station from domestic to very large high-pressure transmission. New techniques are not excluded, provided their proven performance is equivalent to, or better than, that of those techniques referred to in ISO 15112:2011. Gas-measuring systems are not the subject of ISO 15112:2011.

AGA Report Nr 5: 2009 “Natural Gas Energy Measurement” provides methods of calculating heating values of natural gas with different compositions. This revised version contains a program in Excel Spreadsheet for heating values and other related calculations, both in Imperial and SI units.

Gas Measurement Systems
Sampling

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 11: Determination of energy content etc.
Section 17: Requirements relating to sampling

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements – General
Section 4.3: Sampling and analysis equipment
Section 5.1.9: Sales and allocation measurement – Functional requirements – Interface requirements
Section 5.2.2.7: Sales and allocation measurement – Technical require - Mechanical part - Thermal insulation
Section 6.1.9: Fuel gas measurement - Functional requirements - Interface requirements
Section 8.1.1: Gas samplers systems - Functional requirements - General
Section 8.1.3: Gas samplers systems - Functional requirements - Equipment/schematic
Section 8.1.4.1: Gas samplers systems - Functional requirements – Performance - General
Section 8.1.5: Gas samplers systems - Functional requirements – Process/ambient conditions
Section 8.1.6: Gas samplers systems - Functional requirements – Operational requirements
Section 8.1.9: Gas samplers systems - Functional requirements – Layout requirements
Section 8.2.1: Gas samplers systems - Technical requirements - Initial selection of automatic probe location
Section 8.2.2: Gas samplers systems - Technical requirements - Design considerations for sampling systems
Section 8.2.5: Gas samplers systems - Technical requirements - Sampler controller
Section 8.2.7: Gas samplers systems - Technical requirements - Tubing and valves
Section 9.1.3.2: Gas chromatograph - Functional requirements - Equipment/schematic - Sample handling system
Section 9.1.4.2: Gas chromatograph - Functional requirements – Performance - Availability and reliability
Section 9.2.1: Gas chromatograph - Technical requirements - Sample handling system
Annex A: (Normative) Requirements for automated condition based maintenance
Annex B: (Normative) Testing and commissioning

Most Significant Standards

ISO Standards

ISO 10715: 1997 Natural gas -- Sampling guidelines

Abstract of standard

ISO 10715: 1997 “Natural gas - Sampling guidelines” provides concise guidelines for the collection, conditioning and handling of representative samples of processed natural gas streams. It also contains guidelines for sampling strategy, probe location and the handling and design of sampling equipment. It considers spot, composite (incremental) and continuous sampling systems. This document gives consideration to constituents such as oxygen, hydrogen sulfide, air, nitrogen and carbon dioxide in the gas stream. This document does not include sampling of liquid streams or streams with multiphase flow. Traces of liquid, such as glycol and compressor oil, if present, are assumed to be intrusive and not a part of the gas to be sampled. Their removal is desirable to protect the sampling and analytical equipment from contamination. This document can be used for custody transfer measurement systems and allocation measurement systems.

Other relevant Standards

ISO 8943: 2007 Refrigerated light hydrocarbon fluids -- Sampling of liquefied natural gas -- Continuous and intermittent methods

ISO 8943: 2007 “Refrigerated light hydrocarbon fluids -- Sampling of liquefied natural gas -- Continuous and intermittent methods” specifies methods for the continuous and the intermittent sampling of LNG while it is being transferred through an LNG transfer line.

Gas Measurement Systems
Gas Chromatograph

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measuring uncertainty
Section 11: Determination of energy content etc.
Section 15: The instrument part of the metering system
Section 25: Operating requirements for flow meters
Section 26: Operating requirements for instrument part

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.1: General requirements – General
Section 4.3: Sampling and analysis equipment
Section 5.1.9: Sales and allocation measurement – Functional requirements – Interface requirements
Section 5.2.2.7: Sales and allocation measurement – Technical requirements - Mechanical part - Thermal insulation
Section 5.2.3.1: Sales and allocation measurement – Technical requirements - Instrument part - General
Section 5.2.3.9: Sales and allocation measurement – Technical requirements - Instrument part - Calculated density
Section 5.2.4.5: Sales and allocation measurement – Technical requirements - Computer part - Calculations
Section 5.2.4.9: Sales and allocation measurement – Technical requirements - Computer part - Reporting of data
Section 6.1.9: Fuel gas measurement - Functional requirements - Interface requirements
Section 6.2.3.7: Fuel gas measurement - Technical requirements - Instrument part - Density
Section 8.1.1: Gas samplers systems - Functional requirements - General
Section 9: Gas chromatograph
Section 9.1.1: Gas chromatograph - Functional requirements – General
Section 9.1.3.2: Gas chromatograph - Functional requirements – Equipment/schematic - Sample handling system
Section 9.1.3.3: Gas chromatograph - Functional requirements – Equipment/schematic - Analytical unit
Section 9.1.3.4: Gas chromatograph - Functional requirements – Equipment/schematic - Computer unit
Section 9.1.4.1: Gas chromatograph - Functional requirements – Performance - Uncertainty
Section 9.1.4.2: Gas chromatograph - Functional requirements – Performance - Availability and reliability
Section 9.1.5: Gas chromatograph - Functional requirements – Process/ambient conditions
Section 9.2.2: Gas chromatograph - Technical requirements - Analytical unit

Section 9.2.3: Gas chromatograph - Technical requirements - Computer unit
Section 9.2.4: Gas chromatograph - Technical requirements - Calibration equipment
Annex B: (Normative) Testing and commissioning
Annex D (Informative) Example of performance calculation of online gas chromatograph (OGC) result

Most Significant Standards

ISO Standards

ISO 23874: 2006	Natural gas -- Gas chromatographic requirements for hydrocarbon dewpoint calculation
ISO 6974-1: 2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 1: Guidelines for tailored analysis
ISO/FDIS 6974-1: 2011 (2)	
ISO 6974-2: 2001	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 2: Measuring-system characteristics and statistics for processing of data
ISO/FDIS 6974-2: 2011 (2)	
ISO 6974-3: 2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns
ISO 6974-4: 2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 4: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns
ISO 6974-5: 2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 5: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns
ISO/NP 6974-5: 2010 (2)	
ISO 6974-6: 2002	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 6: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns
ISO 6974-6:2002/Cor 1: 2003	
ISO 10723:2002	Natural gas -- Performance evaluation for on-line analytical systems
ISO 14111:1997	Natural gas -- Guidelines to traceability in analysis

(2): Under revision at time of edition.

Abstract of standard

ISO 23874: 2006 “Natural gas -- Gas chromatographic requirements for hydrocarbon dewpoint calculation” describes the performance requirements for analysis of treated natural gas of transmission or pipeline quality in sufficient detail so that the hydrocarbon dewpoint temperature can be calculated using an appropriate equation of state. ISO 23874:2006 can be applied to gases

that have maximum dewpoint temperatures (cricondentherms) between 0 °C and - 50 °C. The pressures at which these maximum dewpoint temperatures are calculated are in the range 2 MPa (20 bar) to 5 MPa (50 bar). The procedure given in ISO 23874:2006 covers the measurement of hydrocarbons in the range C5 to C12. n-Pentane, which is quantitatively measured using ISO 6974 (all parts), is used as a bridge component and all C6 and higher hydrocarbons are measured relative to n-pentane. Major components are measured using ISO 6974 (all parts) and the ranges of components that can be measured are as defined in ISO 6974-1.

ISO 6974-1: 2000 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 1: Guidelines for tailored analysis "gives guidelines for the quantitative analysis of natural-gas-containing constituents within the application ranges given in Table 1. Individual methods, as described in part 3 and subsequent parts of ISO 6974, may have more restricted application ranges than those in Table 1, but in all cases they will fall within this overall scope of the ranges given.

Table 1 — Application ranges

Component	Mole fraction range %
Hydrogen	0,001 to 0,5
Helium	0,001 to 0,5
Oxygen	0,001 to 5
Nitrogen	0,001 to 60
Carbon dioxide	0,001 to 35
Methane	40 to 100
Ethane	0,02 to 15
Propane	0,001 to 25
Butanes	0,000 1 to 5
Pentanes	0,000 1 to 1
Hexanes and heavier	0,000 1 to 0,5

ISO 6974-2: 2001 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 2: Measuring-system characteristics and statistics for processing of data" describes the data processing for the tailored analysis of natural gas. It includes the determination of the measuring system characteristics and the statistical approach to data handling and error calculation with the aim of defining the uncertainty in the mole fractions of the component measured. This part of ISO 6974 is only applicable in conjunction with part 1 of ISO 6974.

ISO 6974-3: 2000 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns" describes a gas chromatographic method for the quantitative determination of the content of helium, hydrogen, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons in natural gas samples using two packed columns. This method is applicable to determinations made in on-line processes or in the laboratory. It is applicable to the analysis of gases containing constituents within the mole fraction ranges given in Table 1 and which do not contain any hydrocarbon condensate. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be detected present, the method can still

be applicable. This part of ISO 6974 is only applicable in conjunction with parts 1 and 2 of ISO 6974.

Table 1 — Application ranges

Component	Mole fraction range %
Helium	0,01 to 0,5
Hydrogen	0,01 to 0,5
Oxygen	0,1 to 0,5
Nitrogen	0,1 to 40
Carbon dioxide	0,1 to 30
Methane	50 to 100
Ethane	0,1 to 15
Propane	0,001 to 5
Butanes	0,000 1 to 2
Pentanes	0,000 1 to 1
Hexanes to octanes	0,000 1 to 0,5

ISO 6974-4: 2000 “Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 4: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns” describes a gas chromatographic method for the quantitative determination of natural gas constituents using a two-column system. This method is applicable to determinations made in on-line processes or in the laboratory. It is applicable to the analysis of gases containing constituents within the mole fraction ranges given in Table 1. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be detected present, the method can still be applicable. This part of ISO 6974 is only applicable if used in conjunction with parts 1 and 2 of ISO 6974.

Table 1 — Application ranges

Component	Mole fraction range %
Nitrogen	0,001 to 15,0
Carbon dioxide	0,001 to 10
Methane	75 to 100
Ethane	0,001 to 10,0
Propane	0,001 to 3,0
iso-Butane (2-methylpropane)	0,001 to 1,0
n-Butane	0,001 to 1,0
neo -Pentane (2,2-dimethylpropane)	0,001 to 0,5
iso -Pentane (2-methylbutane)	0,001 to 0,5
n-Pentane	0,001 to 0,5
Hexanes _ sum of all C6 and higher hydrocarbons	0,001 to 0,2

ISO 6974-5: 2000 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 5: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns" describes a gas chromatographic method for the quantitative determination of natural gas constituents using a three-column system. This method is applicable to natural gases of limited range, on-line and automatically calibrating on a regular basis for gas samples not containing any hydrocarbon condensate and/or water. It is applicable to the analysis of gases containing constituents within the mole fraction ranges given in Table 1. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be detected present, the method can still be applicable. This part of ISO 6974 is only applicable if used in conjunction with parts 1 and 2 of ISO 6974.

Table 1 — Application ranges

Component	Mole fraction range %
Nitrogen	0,001 to 15,0
Carbon dioxide	0,001 to 8,5
Methane	75 to 100
Ethane	0,001 to 10,0
Propane	0,001 to 3,0
iso-Butane (2-methylpropane)	0,001 to 1,0
n-Butane	0,001 to 1,0
neo -Pentane (2,2-dimethylpropane)	0,001 to 0,5
iso-Pentane (2-methylbutane)	0,001 to 0,5
n-Pentane	0,001 to 0,5
Hexanes _ sum of all C6 and higher hydrocarbons	0,001 to 1,0

ISO 6974-6: 2002 "Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 6: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns" describes a gas chromatographic method for the quantitative determination of the content of helium, hydrogen, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons in natural gas samples using three capillary columns. This method is applicable to the determination of these gases within the mole fraction ranges varying from 0,000 1 % to 40 %, depending on the component analyzed, and is commonly used for laboratory applications. However, it is only applicable to methane within the mole fraction range of 40 % to 100 %. These ranges do not represent the limits of detection, but the limits within which the stated precision of the method applies. Although one or more components in a sample may not be present at detectable levels, the method can still be applicable. ISO 6974-6:2002 is only applicable if used in conjunction with ISO 6974-1:2000 and ISO 6974-2:2001. This method can also be applicable to the analysis of natural gas substitutes. Additional information on the applicability of this method to the determination of natural gas substitutes is also given where relevant.

ISO 10723:2002 ‘‘Natural gas -- Performance evaluation for on-line analytical systems. This describes a method of assessing whether an analytical system for natural gas is satisfactory provided that the analytical requirements have been clearly defined and the analytical and calibration procedures have been fully described.

ISO 14111:1997 ‘‘Natural gas -- Guidelines to traceability in analysis’’ - provides general guidelines on the implementation and application of traceability concepts in the analysis of natural gas. Its purpose is to lay down the foundations for the development of specific traceability protocols in other International Standards for natural-gas analysis.

Other relevant Standards

ISO 19739: 2004	Natural gas -- Determination of sulfur compounds using gas chromatography
ISO 6326-1: 2007	Natural gas -- Determination of sulfur compounds -- Part 1: General introduction
ASTM D 1945-03: 2010	Standard Test Method for Analysis of Natural Gas by Gas Chromatography

ISO 19739:2004 “Natural gas -- Determination of sulfur compounds using gas chromatography” specifies the determination of hydrogen sulfide, carbonyl sulfide, C1 to C4 thiols, sulfides and tetrahydrothiophene (THT) using gas chromatography (GC). Depending on the method chosen from those given in its annexes, the application ranges for the determination of sulfur compounds can vary, but whichever of the methods is used, its requirements apply.

ISO 6326-1:2007 “Natural gas -- Determination of sulfur compounds -- Part 1: General introduction” gives a brief description of standardized methods that can be used for the determination of sulfur compounds in natural gas. The principle of each method is described generally, the range of concentrations for which the method is suitable is indicated, and the analytical range and precision of each method is given. It should enable the user to select judiciously the proper method for the application being considered. Sulfur analysis is performed in order to determine total sulfur, sulfur contained in specific groups [e.g. thiols (mercaptans)], individual sulfur compounds and specific groups of sulfur compounds. The available standardized methods in the field of sulfur analysis are the Wickbold combustion method for total sulfur determination (ISO 4260); the Lingener combustion method for total sulfur determination (ISO 6326-5); gas chromatography for determination of individual sulfur compounds (ISO 19739); potentiometry for determination of hydrogen sulfide, carbonyl sulfide and thiol compounds (ISO 6326-3).

ASTM D 1945-03: 2010 “Standard Test Method for Analysis of Natural Gas by Gas Chromatography “covers the determination of the chemical composition of natural gases and similar gaseous mixtures within the range of composition shown in Table 1. This test method may be abbreviated for the analysis of lean natural gases containing negligible amounts of hexanes and higher hydrocarbons, or for the determination of one or more components, as required. The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Laboratory
Density

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measuring uncertainty

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”

Section 4.4: General requirements – Calibration
Section 8.1.1: Gas samplers systems – Functional requirements – General
Annex B: (Normative) Testing and commissioning

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.3: General requirements – Sampling and water fraction metering equipment
Section 5.1.6.1: Sales and allocation measurement - Functional requirements - Operational requirements – General
Section 5.2.4.1: Sales and allocation measurement – Technical requirements – Instrument part – Location of sensor
Section 5.2.4.7: Sales and allocation measurement – Technical requirements – Instrument part – Density
Section 5.2.5.2: Sales and allocation measurement – Technical requirements – Computer part – Computer design
Section 5.2.5.5: Sales and allocation measurement – Technical requirements – Computer part – Calculations
Section 5.2.5.6: Sales and allocation measurement – Technical requirements – Computer part – Check
Annex A: (Normative) Requirements for automated condition based maintenance
Annex D: (Informative) Water in oil calculations

Most Significant Standards

ISO Standards

ISO 3838: 2004	Crude petroleum and liquid or solid petroleum products -- Determination of density or relative density -- Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods
ISO 12185: 1996	Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method
ISO 3993: 1984	Liquefied petroleum gas and light hydrocarbons -- Determination of density or relative density -- Pressure hydrometer method

ISO 3675: 1998	Crude petroleum and liquid petroleum products -- Laboratory determination of density -- Hydrometer method
ISO 15212-1: 1998	Oscillation-type density meters -- Part 1: Laboratory instruments
ISO 15212-2: 2002	Oscillation-type density meters -- Part 2: Process instruments for homogeneous liquids

API Standards

API MPMS 9.1: 2005	Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
API MPMS 9.2: 2007	Standard Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer
API MPMS 9.3: 2008	Standard Test Method for Density, Relative Density, and API Gravity of Crude Petroleum and Liquid Petroleum Products by Thermohydrometer Method

Abstract of standard

ISO 3838: 2004 “Crude petroleum and liquid or solid petroleum products -- Determination of density or relative density -- Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods” specifies methods for the determination of the density or relative density of crude petroleum and of petroleum products handled as liquids. The capillary-stoppered pyknometer method is also for use with solids and this method may also be used for coal tar products, including road tars, creosote and tar pitches, or for mixtures of these with petroleum products. This method is not suitable for the determination of the density or relative density of highly volatile liquids having Reid vapour pressures greater than 50 kPa according to ISO 3007 or having an initial boiling point below 40 degrees Celsius. The graduated bicapillary pyknometer method is recommended for the accurate determination of the density or relative density of all except the more viscous products, and is particularly useful when only small amounts of samples are available. The method is restricted to liquids having Reid vapour pressures of 130 kPa or less according to ISO 3007 and having kinematic viscosities less than 50 mm2/s (50 centistokes (cSt)) at the test temperature. Special precautions are specified for the determination of the density or relative density of highly volatile liquids.

ISO 12185: 1996 “Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method” gives a method for the determination, using an oscillation U-tube densitometer, of the density of crude petroleum and related products within the range 600 kg/m^3 to 1 100 kg/m^3 which can be handled as single-phase liquids at the test temperature and pressure.

ISO 3993: 1984 “Liquefied petroleum gas and light hydrocarbons -- Determination of density or relative density -- Pressure hydrometer method” prescribed apparatus shall not be used for materials having gauge vapour pressures higher than 1,4 MPa (absolute vapour pressure 1,5 MPa) at the test temperature. Alternative calibration procedures are described, but only the one using a certified hydrometer is suitable for the determination of density to be used in calculations of qualities for custody transfer or fiscal purposes.

API MPMS 9.1: 2005 “Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method” describes the methods and practices relating to the determination of the density, relative density, or API gravity of crude petroleum and liquid petroleum products using the hydrometer method (laboratory determination).

API MPMS 9.2: 2007 “Standard Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer” provides a guide for determining the density or relative density (specific gravity) or API gravity of light hydrocarbons, including liquefied petroleum gases, using a pressure hydrometer.

API MPMS 9.3: 2008 “Standard Test Method for Density, Relative Density, and API Gravity of Crude Petroleum and Liquid Petroleum Products by Thermohydrometer Method” describes methods and practices suitable for the determination of density or API gravity of crude petroleum and liquid petroleum products using thermohydrometers. The test method covers petroleum and liquid petroleum products with Reid vapor pressure of 179 kPa (26 psi) or less.

Other relevant Standards

ISO 649-1: 1981	Laboratory glassware -- Density hydrometers for general purposes -- Part 1: Specification
ISO 649-2: 1981	Laboratory glassware -- Density hydrometers for general purposes -- Part 2: Test methods and use

ISO 649-1: 1981 “Laboratory glassware -- Density hydrometers for general purposes -- Part 1: Specification” specifies the requirements for basic series and sub-series of glass hydrometers of constant mass without built-in thermometer. They are graduated to indicate density at 20 degrees centigrade and 15 degrees centigrade, respectively. Standard categories of surface tension are tabled in annex A, recommended stem diameters in annex B.

ISO 649-2: 1981 “Laboratory glassware -- Density hydrometers for general purposes -- Part 2: Test methods and use” specifies the determination of the density considering general procedures. Apparatus and readings of the density and temperature are described and also the application of the corrections. In drawings the construction and the dimensions of suitable vessels are shown.

Laboratory

Water in Oil and Sediments

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

Section 8: Allowable measuring uncertainty

NORSOK References

NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

Section 4.1: General requirements – General
Section 4.3: General requirements – Sampling and water fraction metering equipment
Section 6: Water in oil measurement
Section 6.1.1: Water in oil measurement – Functional requirements – General
Section 6.1.4.1: Water in oil measurement – Functional requirements – Performance - Capacity
Section 6.1.4.2: Water in oil measurement – Functional requirements – Performance – Uncertainty
Section 6.1.5: Water in oil measurement – Functional requirements – Process/Ambient conditions
Section 6.1.6: Water in oil measurement – Functional requirements – Operational requirements
Section 6.1.7.3: Water in oil measurement – Functional requirements – Maintenance requirements – Layout requirements
Section 6.2.1: Water in oil measurement – Technical requirements – Mechanical part
Section 6.2.2: Water in oil measurement – Technical requirements – Instrument part
Section 6.2.3: Water in oil measurement – Technical requirements – Computer part
Annex D: (Informative) Water in oil calculations

Most Significant Standards

ISO Standards

ISO 9030: 1990	Crude petroleum -- Determination of water and sediment -- Centrifuge method
ISO 9029: 1990	Crude petroleum -- Determination of water -- Distillation method
ISO 10336: 1997	Crude petroleum -- Determination of water -- Potentiometric Karl Fischer titration method
ISO 10337: 1997	Crude petroleum -- Determination of water -- Coulometric Karl Fischer titration method
ISO 6296: 2000	Petroleum products -- Determination of water -- Potentiometric Karl Fischer titration method
ISO 12937: 2000	Petroleum products -- Determination of water -- Coulometric Karl Fischer titration method

API Standards

API MPMS 10.3: 2008	Standard Test Method for Water and Sediment in Crude Oil by the Centrifuge Method (Laboratory Procedure)
API MPMS 10.6: 2009	Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
API MPMS 10.7: 2006	Standard Test Method for Water in Crude Oils by Potentiometric Karl Fischer Titration
API MPMS 10.8: 2010	Standard Test Method for Sediment in Crude Oil by Membrane Filtration
API MPMS 10.9: 2010	Standard Test Method for Water in Crude Oils by Coulometric Karl Fischer Titration

Abstract of standard

ISO 9030: 1990 “Crude petroleum -- Determination of water and sediment -- Centrifuge method” specifies a method for the laboratory determination. The precision data of this procedure have only been determined for water contents up to 1 % (V/V). Includes principle, apparatus, reagents, sampling, procedure, expression of results, precision and test report. A centrifuge tube is shown in figure 1. The procedure for reading the volume of water and sediment is shown in figure 2. The precision of the method is shown in figure 3. The sample handling is described in annex A.

ISO 9029: 1990 “Crude petroleum -- Determination of water -- Distillation method”. The precision data of this procedure have only been determined for water contents up to 1 % (V/V). Includes principle, apparatus, solvent, calibration and recovery test, sampling, procedure, expression of results, precision and test report. The distillation apparatus is shown in figures 1 and 2. The precision of the method is shown in figure 3. The sample handling is described in annex A.

API MPMS 10.3: 2008 “Standard Test Method for Water and Sediment in Crude Oil by the Centrifuge Method (Laboratory Procedure)” describes a method of laboratory determination of water and sediment in crude oil by means of the centrifuge procedure.

API MPMS 10.6: 2009 “Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)” describes the laboratory determination of water and sediment in fuel oils in the range from 0 to 30 % volume by means of the centrifuge procedure.

API MPMS 10.7: 2006 “Standard Test Method for Water in Crude Oils by Potentiometric Karl Fischer Titration” describes the procedure for the determination of water in crude oils by Karl Fischer titration (potentiometric.) This test method covers the determination of water in the range from 0.02 to 2 mass percent in crude oils. Mercaptan and sulfide (S^{-} or H2S) sulfur are known to interfere with the method.

API MPMS 10.8: 2010 “Standard Test Method for Sediment in Crude Oil by Membrane Filtration” covers the determination of sediment in crude oils by membrane filtration. This test method has been validated for crude oils with sediments up to approximately 0.15 mass %. The accepted unit of measure for this test method is mass %, but an equation to convert to volume % is provided.

API MPMS 10.9: 2010 “Standard Test Method for Water in Crude Oils by Coulometric Karl Fischer Titration” covers the determination of water in the range from 0.02 to 5.0 percent in crude oils. The test method presents two procedures for the direct determination of water content in crude oils; weight and volume.

Other relevant Standards

ISO 3734: 1997	Petroleum products - Determination of water and sediment in residual fuel oils - Centrifuge method
ISO 3733: 1999	Petroleum products and bituminous materials -- Determination of water - Distillation method

Multiphase Flow Regime
Multiphase Meters

NPD Regulations

Regulations relating to measurement of Petroleum for Fiscal purposes and for calculation of CO2 tax (The Measurement regulation): 2009

No specific standards

NORSOK References

NORSOK Standard I-104: 2005 “Fiscal measurement systems for hydrocarbon gas”
NORSOK Standard I-105: 2007 “Fiscal measurement systems for hydrocarbon liquid”

No specific standards

Most Significant Standards

NFOGM Documents

Handbook Revision 2: 2005	Handbook of Multiphase Flow Metering

API Documents

API MPMS RP 86: 2005	Recommended Practice for Measurement of Multiphase Flow
API MPMS Publ 2566 : 2004	State of the Art Multiphase Flow Metering

ISO Documents

ISO/PRF TR 11583: 2011 (1)	Measurement of wet gas flow by means of pressure differential devices inserted in circular cross-section conduits

(1): Not published at time of edition.

NFOGM Handbook Revision 2: 2005 “Handbook of Multiphase Flow Metering” is intended to serve as a guide for users and manufacturers of MPFMs. Its purpose is to provide a common basis for, and assistance in, the classification of applications and meters, as well as guidance and recommendations for the implementation and use of such meters. The document may 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. The so-called in-line MPFMs that directly measure the oil, water and gas flow rates without any conditioning, as well as the partial- and full separation MPFMs are the main focus of the Handbook. Conventional two- or three-phase separators are not included here. It should be emphasized however that in contrast to the previous Handbook, this version also covers wet gas meters and their applications,

since wet gas is considered as a subset of multiphase flows. Even if the individual flow rates of each constituent are of primary interest, often their ratios (Water-in-Liquid Ratio, Gas/Oil Ratio, etc) are useful as operational parameters. Constituents other than oil, gas and water flow rates or ratios of these are not dealt with here. The performance of a multiphase flow meter in terms of uncertainty, repeatability, range, etc. is of great importance, as this enables the user to compare different meters and evaluate their suitability for use in specific applications. Section 8 covers this issue in detail and proposes standard methods to describe performance. The testing and qualification of the meters is also related to performance. Guidance is provided to help optimise the outcome of such activities. Since MPFMs measure at line conditions, the primary output is individual flow rates and fractions at actual conditions (e.g. 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 and may involve multiphase sampling. The conversion from actual conditions to standard conditions is not included here.

API MPMS RP 86: 2005 “Recommended Practice for Measurement of Multiphase Flow” addresses how the user measures (multiphase) flow rates of oil, gas, water, and any other fluids that are present in the effluent stream of a single well. This requires the definition not only of the methodology which is to be employed, but also the provision of evidence that this methodology will produce a quality measurement in the intended environment. Most often, this evidence will take the form of a statement of the uncertainty of the measurement, emphasizing how the uncertainty statement was derived.

API MPMS Publ 2566 : 2004 “State of the Art Multiphase Flow Metering” provides information on multiphase flow metering systems gleaned from more than 150 published documents that are in the public domain. The documentation was prepared from information obtained through mid-2002. It should be noted that the indicated performances data stated in these published documents have not necessarily been verified by an independent body. The listing of these references in the Appendix 2 is intended to provide a comprehensive source of data and information on multiphase metering; the reader needs to carefully review the source of the data in the documents when utilizing the information.

National and International Organizations for Standardization & Regulation Addresses and links

ISO (International Organization for Standardization)

1, ch. de la Voie-Creuse
Case Postale 56
1211 Genève 20
Switzerland
www.iso.org

API (American Petroleum Institute)

1220 L Street, Northwest
Washington DC 20005
USA
www.api.org

AGA (American Gas Association)

400 North Capitol Street, NW
Washington DC 20001
USA
www.aga.org

GPA (Gas Processor Association)

6526 E. 60th Street,
Tulsa OK 74145
USA
www.gpaglobal.org

ENERGY INSTITUTE

61 New Cavendish Street
London W1G 7AR
UK
www.energyinst.org

Norwegian Petroleum Directorate

Professor Olav Hanssens vei 10, PB 600
NO-4003 Stavanger
Norway
www.npd.no

Standards Norway

Strandveien 18
NO-1326 Lysaker
Norway
www.standard.no

OIML (International Organization for Legal Metrology)

11, rue Turgot
75009 Paris
France
www.oiml.org

STANDARDS RELATING TO MEASUREMENT OF PETROLEUM

List of Standards

ISO 91-1: 1992	Petroleum measurement tables -- Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F	23, 50
ISO 91-2: 1991	Petroleum measurement tables -- Part 2: Tables based on a reference temperature of 20 degrees C	23, 50
ISO 1998-6: 2000	Petroleum industry -- Terminology -- Part 6: Measurement	22
ISO 2186:2007	Measurement of fluid flow in closed conduits -- Connections for pressure signal transmissions between primary and secondary elements	71
ISO 2714: 1980	Liquid hydrocarbons -- Volumetric measurement by displacement meter systems other than dispensing pumps	23, 28
ISO 2715: 1981	Liquid hydrocarbons -- Volumetric measurement by turbine meter systems	23, 26
ISO 2909: 2002	Petroleum products -- Calculation of viscosity index from kinematic viscosity	48
ISO 3170: 2004	Petroleum liquids - Manual sampling	37
ISO 3171: 1988	Petroleum liquids -- Automatic pipeline sampling	37
ISO 3675: 1998	Crude petroleum and liquid petroleum products - Laboratory determination of density - Hydrometer method	43, 86
ISO 3733: 1999	Petroleum products and bituminous materials -- Determination of water - Distillation method	90
ISO 3734: 1997	Petroleum products - Determination of water and sediment in residual fuel oils - Centrifuge method	46, 90
ISO 3735: 1999	Crude petroleum and fuel oils - Determination of sediment - Extraction method	46
ISO 3838: 2004	Crude petroleum and liquid or solid petroleum products - Determination of density or relative density - Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods	42, 85
ISO 3993: 1984	Liquefied petroleum gas and light hydrocarbons - Determination of density or relative density - Pressure hydrometer method	43, 85
ISO 4124: 1994	Liquid hydrocarbons -- Dynamic measurement -- Statistical control of volumetric metering systems	23, 52
ISO 4257: 2007	Liquefied petroleum gases -- Method of sampling	38
ISO 4267-2: 1988	Petroleum and liquid petroleum products - Calculation of oil quantities - Part 2: Dynamic measurement	50
ISO 5024: 1999	Petroleum liquids and liquefied petroleum gases - Measurement - Standard reference conditions	6
ISO 5167-1: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 1: General principles and requirements	56,71
ISO 5167-2: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 2: Orifice plates	56, 71
ISO 5167-3: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 3: Nozzles and Venturi nozzles	56, 71
ISO 5167-4: 2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -- Part 4: Venturi tubes	56, 71
ISO 5168:2005	Measurement of fluid flow - Procedures for the evaluation of uncertainties	15
ISO 6296: 2000	Petroleum products -- Determination of water -- Potentiometric Karl Fischer titration method	88
ISO 6326-1: 2007	Natural gas -- Determination of sulfur compounds -- Part 1: General introduction	84
ISO 6551: 1982	Petroleum liquids and gases -- Fidelity and security of dynamic measurement -- Cabled transmission of electric and/or electronic pulsed data	26, 28, 30, 32, 67
ISO 6974-1: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 1: Guidelines for tailored analysis	15, 80
ISO/FDIS 6974-1: 2011		80
ISO 6974-2: 2001	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 2: Measuring-system characteristics and statistics for processing of data	15, 80
ISO/FDIS 6974-2: 2011		80
ISO 6974-3: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns	15, 80
ISO 6974-4: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 4: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns	15, 80
ISO 6974-5: 2000	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 5: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns	15, 80
ISO/NP 6974-5: 2010		80
ISO 6974-6: 2002	Natural gas - Determination of composition with defined uncertainty by gas chromatography - Part 6: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns	16, 80
ISO 6976: 1995	Natural gas -- Calculation of calorific values, density, relative density and Wobbe index from composition	72, 75
ISO/TR 7066-1: 1997	Assessment of uncertainty in calibration and use of flow measurement devices - Part 1: Linear calibration relationships	16
ISO 7066-2: 1988	Assessment of uncertainty in the calibration and use of flow measurement devices - Part 2: Non-linear calibration relationships	16
ISO 7278-1: 1987	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters -- Part 1: General principles	35
ISO 7278-2: 1988	Liquid hydrocarbons - Dynamic measurement -- Proving systems for volumetric meters -- Part 2: Pipe provers	35
ISO 7278-3: 1998	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters -- Part 3: Pulse interpolation techniques	35
ISO 7278-4: 1999	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 4: Guide for operators of pipe provers	35

STANDARDS RELATING TO MEASUREMENT OF PETROLEUM

ISO 8222:2002	Petroleum measurement systems - Calibration -- Temperature corrections for use when calibrating volumetric proving tanks	33
ISO 8310: 1991	Refrigerated light hydrocarbon fluids - Measurement of temperature in tanks containing liquefied gases - Resistance thermometers and thermocouples	41
ISO 8943: 2007	Refrigerated light hydrocarbon fluids -- Sampling of liquefied natural gas -- Continuous and intermittent methods	78
ISO 9000: 2005	Quality management systems -- Fundamentals and vocabulary	8
ISO 9001: 2008	Quality management systems - Requirements	8
ISO 9004: 2009	Managing for the sustained success of an organization - A quality management approach.	9
ISO 9029: 1990	Crude petroleum -- Determination of water -- Distillation method	88
ISO 9030: 1990	Crude petroleum - Determination of water and sediment - Centrifuge method	45, 88
ISO 9300: 2005	Measurement of gas flow by means of critical flow Venturi nozzles	58
ISO/TR 9464: 2008	Guidelines for the use of ISO 5167:2003	58
ISO 9770: 1989	Crude petroleum and petroleum products -- Compressibility factors for hydrocarbons in the range 638 kg/m^3 to 1 074 kg/m^3	23, 50
ISO 9951:1993	Measurement of gas flow in closed conduits -- Turbine meters	66
ISO 10005: 2005	Quality management systems - Guidelines for quality plans	9
ISO/TR 10013: 2001	Guidelines for quality management system documentation	9
ISO 10307-1: 2009	Petroleum products - Total sediment in residual fuel oils - Part 1: Determination by hot filtration	46
ISO 10307-2: 2009	Petroleum products - Total sediment in residual fuel oils - Part 2: Determination using standard procedures for ageing	46
ISO 10336: 1997	Crude petroleum -- Determination of water -- Potentiometric Karl Fischer titration method	88
ISO 10337: 1997	Crude petroleum -- Determination of water -- Coulometric Karl Fischer titration method	88
ISO 10715: 1997	Natural gas -- Sampling guidelines	78
ISO 10723:2002	Natural gas -- Performance evaluation for on-line analytical systems	80
ISO 10790: 1999	Measurement of fluid flow in closed conduits -- Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)	23, 30, 43, 64
ISO/PRF TR 11583: 2011	Measurement of wet gas flow by means of pressure differential devices inserted in circular cross-section conduits	91
ISO 11631: 1998	Measurement of fluid flow -- Methods of specifying flowmeter performance	22
ISO 12185: 1996	Crude petroleum and petroleum products - Determination of density - Oscillating U-tube method	43, 85
ISO 12213-1: 2006	Natural gas -- Calculation of compression factor -- Part 1: Introduction and guidelines	73
ISO 12213-2: 2006	Natural gas -- Calculation of compression factor -- Part 2: Calculation using molar-composition analysis	73
ISO 12213-3: 2006	Natural gas -- Calculation of compression factor -- Part 3: Calculation using physical properties	73
ISO/DIS 12242 (1)	Measurement of fluid flow in closed conduits - Ultrasonic meters for liquid	32
ISO/TR 12767: 2007	Measurement of fluid flow by means of pressure differential devices -- Guidelines on the effect of departure from the specifications and operating conditions given in ISO 5167	58
ISO 12937: 2000	Petroleum products -- Determination of water -- Coulometric Karl Fischer titration method	88
ISO 13443: 1996	Natural gas - Standard reference conditions	6
ISO/DTR 13587 (1)	Three statistical approaches for the assessment and interpretation of measurement uncertainty	15
ISO 14111:1997	Natural Gas -- Guidelines to traceability in analysis	80
ISO 14532:2001	Natural Gas Vocabulary	54
ISO 15112: 2011	Natural gas -- Energy determination	75
ISO 15212-1: 1998	Oscillation-type density meters -- Part 1: Laboratory instruments	42, 86
ISO 15212-2: 2008	Oscillation-type density meters -- Part 2: Process instruments for homogeneous liquids	42, 86
ISO/TR 15377: 2007	Measurement of fluid flow by means of pressure-differential devices -- Guidelines for the specification of orifice plates, nozzles and Venturi tubes beyond the scope of ISO 5167	58
ISO 15970: 2008	Natural gas -- Measurement of properties -- Volumetric properties: density, pressure, temperature and compression factor	69, 73
ISO 15971: 2008	Natural gas -- Measurement of properties -- Calorific value and Wobbe index	75
ISO/IEC 17021: 2011	Conformity assessment -- Requirements for bodies providing audit and certification of management systems	12
ISO/IEC 17025: 2005	General requirements for the competence of testing and calibration laboratories	11
ISO 17089-1: 2010	Measurement of fluid flow in closed conduits - Ultrasonic meters for gas - Part 1: Meters for custody transfer and allocation measurement	62
ISO/DIS 17089-2	Measurement of fluid flow in closed conduits - Ultrasonic meters for gas -- Part 2: Meters for industrial applications	62
ISO 19011: 2002	Guidelines for quality and/or environmental management systems auditing	9
ISO 19739: 2004	Natural gas -- Determination of sulfur compounds using gas chromatography	84
ISO 20765-1: 2005	Natural gas -- Calculation of thermodynamic properties -- Part 1: Gas phase properties for transmission and distribution applications	62, 73
ISO 20815: 2008	Petroleum, petrochemical and natural gas industries - Production assurance and reliability management	8
ISO 21748: 2010	Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation	16
ISO 23874: 2006	Natural gas -- Gas chromatographic requirements for hydrocarbon dewpoint calculation	80
ISO/TS 29001: 2010	Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations	9
CEI 60751: 2008	Industrial platinum resistance thermometers and platinum temperature sensors	41, 69
ISO 80000-1: 2009	Quantities and Units – Part 1 : General	6
ISO/IEC Guide 28: 2004	Conformity assessment -- Guidance on a third-party certification system for products	12
ISO/IEC Guide 98-1: 2009	Uncertainty of measurement -- Part 1: Introduction to the expression of uncertainty in measurement	14
ISO/IEC NP Guide 98-2	Uncertainty of measurement - Part 2: Concepts and basic principles	15
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