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ISO /TC 28/SC 2/WG 4

Secretariat: BSI

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Petroleum measurement systems — Metering of viscous and high temperature liquids

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Systèmes de mesure du pétrole - comptage demesurage des produits pétroliers — Comptage des liquides visqueux et à haute température

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Contents

Foreword

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

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

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at ~~www.iso.org/patents.~~www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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

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

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

This second edition cancels and replaces the first edition (ISO 9200:1993), which has been technically revised.

The main changes are as follows:

— mass and volumetric metering is now covered;

— ~~—~~a description and definition of viscosity has been added along with a clarification of high viscosity and high temperature;

— ~~—~~the emphasis on positive displacement meters has been replaced by descriptions of other meter types including ultrasonic, Coriolis and differential pressure devices.

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

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Introduction

This document is intended to guide users in the design, installation, operation, and proving of flowmeters, and their auxiliary equipment, used in the dynamic metering of viscous liquids. It also provides guidance when elevated operating temperatures are used to reduce viscosity. The document applies to Newtonian, hydrocarbon and petroleum liquids. Extra consideration should be given when using other liquids and non-Newtonian liquids.

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The objective of this document is to highlight the considerations to be taken into account when metering high viscosity liquids at normal and elevated temperatures ~~additional~~, in addition to the normal application of metering less viscous liquids at ambient temperatures.

As the viscosity of a liquid increases, the resistance to flow increases. In a fluid transfer system, this generally means that the maximum flowrate achievable for any given conduit size is reduced to avoid excessive pressure loss. This generally results in lower velocities within the measurement system than would be found in lower viscosity applications. As most flow sensors and meters require a minimum velocity to provide reasonable resolution of measurement, the operational range of the flowmeter chosen can be reduced.

Each flowmeter type and design has different limitations on the viscosity and flow range across which it operates at an acceptable accuracy. For higher viscosities and low velocities, it is probable that for many applications the flow regime is laminar rather than turbulent which again affects the performance of flowmeters.

To provide efficient transport of the fluid within a pipe, viscous liquids are often heated to reduce the viscosity. Measuring systems and the associated flowmeters are therefore selected and operated to suit the chosen operating temperature, taking into account changes in temperature and viscosity from ambient conditions.

The behaviour of the fluid should be considered carefully to ~~recognise~~recognize the potential for the liquid to solidify during idle periods and also to manage the potential for air, gas, solids, and wax~~,~~ content from damaging or affecting the metering system.

This document supplements ~~the guidance given in~~ the guidance documents applicable to different flowmeter designs and proving methods in the relevant ISO standards referenced in the bibliography.

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Petroleum measurement systems – — Metering of viscous and high temperature liquids

1 Scope

This document gives guidance whenfor measuring a quantity of primarily viscous hydrocarbon liquid is measured using flowmeters at ambient or elevated operating temperatures.

The objective of this document is to highlight considerations when metering high viscosity liquids at normal and elevated temperatures from the normal application of metering less viscous liquids at ambient temperature.

This document describes the effects of high viscosities and potentially high temperatures, which can induce additional errors in measurement and. It also gives guidance on how to overcome or mitigate difficulties.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1 Definitions

3.1.1
density

mass in a given volume

3.1.2
performance indicator
derived value which relates the meter output to the quantity measured and can be used to indicate the performance of the meter

EXAMPLE: Error, meter factor, K-factor, and discharge coefficient.

3.1.3
pipe prover
displacement prover
device where athe volume of a fluid is displaced from athe calibrated length of a pipe and used to provide a calibration reference for flowmeters

3.1.4
pour point
lowest temperature at which a liquid product loses its flow characteristics and, under specified conditions, ceases to flow

Note 1 to entry: The temperature at which a liquid ceases to flow is based on a standard test.

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3.~~1.~~5
Reynolds number
dimensionless number expressing the ratio between the inertia forces and viscous forces within a flowing fluid

Note 1 to entry: The Reynolds number can provide an indication of the flow profile within a pipe. Generally, numbers below 2 000 indicate a laminar flow, while a number higher than 5 000 indicates a turbulent flow.

Note 2 to entry: The Reynolds number and performance indicator for some flowmeters provides a single relationship which accounts for variations in viscosity as well as flowrate.

3.~~1.~~6
viscosity
measure of resistance to flow

3.~~1.~~7
dynamic viscosity
viscosity dynamic
viscosity absolute
ratio of shear stress to shear rate within the fluid, hence the force needed to overcome internal friction

Note 1 to entry: The unit of absolute viscosity is Pascal second (Pa s). The unit of ~~centiPoise~~centipoise (cP) is commonly used in practice. 1cP = (1 × 10⁻³ Pa s).

3.~~1.~~8
kinematic viscosity
viscosity kinematic
ratio of *dynamic viscosity* ~~(3.1.7)~~(3.7) to *density* ~~(3.1.1)~~(3.1)

Note 1 to entry: The unit of kinematic viscosity is metre square per second ($m^2 s^{-1}$). The unit ~~centiStoke~~centistoke (cSt) is commonly used in practice. 1cSt = (10^{-6} m^2 s^{-1}) = (1 mm^2 s^{-1}). The unit ~~1~~ mm^2 s^{-1} is used throughout this document when giving examples of fluid viscosity.

3.~~1.~~9
performance indicator
derived value which may be used to indicate the performance of the meter

~~Note 1 to entry: Examples of performance indicators are error~~EXAMPLE Error, K-factor, meter factor or discharge coefficient.

3.~~1.~~10
volumetric measure
measure used to provide an accurate measurement of volume to provide a reference for other volume measuring devices

3.~~1.~~11
wax point
cloud point
wax precipitation point
temperature at which wax precipitates from a hydrocarbon liquid

~~**3.2 Symbols and units**~~

~~For the purposes of this document, the symbols used are given within the text~~

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4 Properties of high viscosity liquids

4.1 Viscosity

In this document a viscous liquid is any liquid that requires special treatment or equipment in its handling or storage because of its resistance to flow at either ambient or operating temperature. The liquid is assumed to be Newtonian. If the fluid is non-Newtonian, additional influences on metering should be considered.

Viscosity is typically expressed as being either dynamic or kinematic.

Dynamic viscosity (μ) and kinematic viscosity (υ) are related through density (ρ) by ~~Formula (1).~~Formula (1).

$$\mu = \nu\rho \quad (1)$$

where

μ	is the dynamic viscosity, expressed in Pascal seconds (Pa s);
ρ	is the density, expressed in kilograms per cubic metre (kg m^{-3});
ν	is the kinematic viscosity, expressed in metre square per second (m^2 s^{-1}).

When applying this conversion, or any other use of a viscosity relationship, consistent and matching units should be used~~ and, to avoid error, the use of~~. Using the relevant SI unit ~~is recommended~~as given in Formula (1) helps to avoid error.

4.2 Reynolds number and flow profile

The Reynolds number provides a scale to represent the turbulence within a flowing fluid, hence providing a guide to the velocity profile within a pipe. The Reynolds number is calculated from ~~Formula (2).~~Formula (2).

$$Re = \frac{VD\rho}{\mu} = \frac{VD}{\upsilon} \quad (2)$$

where

D	is the pipe internal diameter, expressed in metres (m);
V	is the mean pipe velocity, expressed in ~~metre square per second (mm~~m^2 s^{-1}~~)~~;
ρ	is the density~~ (~~, expressed in kg m^{-3}~~);~~;
μ	is the dynamic viscosity~~ (~~, expressed in Pa s~~);~~;
ν	is the kinematic viscosity~~ (~~, expressed in m^2 s^{-1}~~)~~.

When calculating the Reynolds number, it is important to ensure the units used are consistent~~ and the use of~~. Using the relevant SI unit ~~is recommended.~~as given in Formula (2) helps to avoid error.

Generally, laminar flow is present at Reynolds numbers below ~~2 000~~2 000 and turbulent flow at Reynolds numbers above ~~5 000~~5 000. Between ~~2 000~~2 000 and ~~5 000~~5 000, a transitional condition is found where either laminar or turbulent or a changing flow condition exists. Within the transitional range, the condition can switch between regimes. These values are indicative and the Reynolds numbers at which the transition between laminar and turbulent flow occurs is variable and depends on of a variety of factors. These include, but are not limited to, pipe configuration, pipe roughness, temperature, orientation and vibration. Typically,

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