BS EN ISO 8222:2020+A1:2022

BSI Standards Publication

Petroleum measurement systems — Calibration — Volumetric measures, proving tanks and field measures (including formulae for properties of liquids and materials)

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National foreword

This British Standard is the UK implementation of EN ISO 8222:2020+A1:2022. It is identical to ISO 8222:2020, incorporating amendment 1:2022. It supersedes BS EN ISO 8222:2020, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to ISO text carry the number of the ISO amendment. For example, text altered by ISO amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee PTI/12, Petroleum Measurement and Sampling.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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28 February 2022	Implementation of ISO amendment 1:2022 with CEN endorsement A1:2022

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 8222

April 2020

ICS 75.180.30

Supersedes EN ISO 8222:2002

English Version

Petroleum measurement systems - Calibration - Volumetric measures, proving tanks and field measures (including formulae for properties of liquids and materials) (ISO 8222:2020)

Systèmes de mesure du pétrole - Étalonnage - Contenants de mesure volumétriques, jauges étalons et contenants de mesure de travail (y compris les formules relatives aux propriétés des liquides et des matériaux) (ISO 8222:2020)

Messsysteme für Mineralölerzeugnisse - Kalibrierung - Temperaturkorrekturen zur Anwendung auf volumetrische Bezugsmessbehälter (ISO 8222:2020)

This European Standard was approved by CEN on 17 February 2020.

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European foreword

This document (EN ISO 8222:2020) has been prepared by Technical Committee ISO/TC 28 "Petroleum and related products, fuels and lubricants from natural or synthetic sources" in collaboration with Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin.” the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2020, and conflicting national standards shall be withdrawn at the latest by October 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 8222:2002.

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Endorsement notice

The text of ISO 8222:2020 has been approved by CEN as EN ISO 8222:2020 without any modification.

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European foreword to amendment A1:2022

This document (EN ISO 8222:2020+A1:2022) has been prepared by Technical Committee ISO/TC 28 "Petroleum and related products, fuels and lubricants from natural or synthetic sources" in collaboration with Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin” the secretariat of which is held by NEN.

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Endorsement notice to amendment A1:2022

The text of ISO 8222:2020+A1:2022 has been approved by CEN as EN ISO 8222:2020+A1:2022 without any modification.

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Foreword

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

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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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 19, *Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 8222:2002), which has been technically revised. The main changes to the previous edition are as follows:

— revision of the title and scope to allow the document to cover the design, calibration and use of a wide range of volumetric measures comprising proving tanks, test measures, field and standard measures;

— provision of revised, updated and extended formulae to allow calculation of temperature correction including the addition of formulae for saline water, other liquids and material properties.

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.

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Introduction

Volumetric, or capacity, measures are used to provide an accurate measure of volume, thereby providing a calibration reference for other volume-measuring devices, such as pipe displacement provers or flowmeters.

Volume measures are categorized in terms of capacity, test measures being below 20 l. Measures above 20 l are categorised as prover tanks. Standard measures are designed to comply with regulatory guidance and hence have specified volumes. Other measures have non-standard volumes specifically designed to suit an application, for example measures to accompany a small volume prover.

Volumetric measures can be used to calibrate flowmeters, both duty and reference meters. They can also be used to calibrate secondary volume measures, displacement (pipe) provers and storage tanks.

Annex A provides the recommended formulae used in the calibration and use of volumetric measures and for other volumetric measurements. This includes pure and saline water properties, the properties of hydrocarbon liquids and the materials of construction of volumetric measuring devices.

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INTERNATIONAL STANDARD **ISO 8222:2020**

Petroleum measurement systems — Calibration — Volumetric measures, proving tanks and field measures (including formulae for properties of liquids and materials)

WARNING — The use of this document could involve hazardous materials, operations and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices.

1 Scope

This document describes the design, use and calibration of volumetric measures (capacity measures) which are intended for use in fixed locations in a laboratory or in the field. This document gives guidance on both standard and non-standard measures. It also covers portable and mobile measures. This document is applicable to the petroleum industry; however, it may be applied more widely to other applications.

This document excludes measures for cryogenic liquids and pressurized measures as used for liquid petroleum gas (LPG) and liquefied natural gas (LNG).

Volumetric measures are classified as test measures or prover tanks depending on capacity and design.

Measures described in this document are primarily designed, calibrated and used to measure volumes from a measure which is wetted and drained for a specified time before use and designated to deliver. Many of the provisions, however, apply equally to measures which are used to measure a volume using a clean and dry measure and designated to contain.

Guidance is given regarding commonly expected uncertainties and calibration specifications.

The document also provides, in Annex A, reference formulae describing the properties of water and other fluids and materials used in volumetric measurement more generally.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, symbols and units

3.1 Terms and definitions

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

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

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

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

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3.1.1
accuracy
closeness of the agreement between a measured quantity value and a true quantity value of a measurand

Note 1 to entry: The concept 'measurement accuracy' is not a quantity and should not be given a numerical value. The quantitative expression of accuracy should be in terms of uncertainty. "Good accuracy" or "more accurate" implies small measurement error. Any given numerical value should be taken as indicative of this.

[SOURCE: VIM:2012, 2.13]

3.1.2
adjustment
set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Adjustment should not be confused with calibration, which is a prerequisite for adjustment.

Note 2 to entry: After adjustment, a recalibration is usually required.

[SOURCE: VIM:2012, 3.11]

3.1.3
automatic pipette
overflow pipette
high precision measure, where the volume withdrawn is defined by a top overflow weir rather than a gauge scale

3.1.4
brim measure
field measure where the volume is defined by an overflow from the top edge of the neck

3.1.5
calibration
operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and in a second step uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A simplified definition is 'set of operations that establish, under specified conditions, the relationship between quantities indicated by an instrument and the corresponding values realized by standards'.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system.

Note 3 to entry: The word "proving" is used in the oil industry and has the same meaning but can include a check of the results against specified acceptance criteria.

[SOURCE: VIM:2012, 2.39]

3.1.6
calibrated volume
volume of a measure between a top and bottom datum as determined by calibration and expressed at a standard temperature

3.1.7
clingage
film of liquid that adheres to the inside surface of a volumetric measure after it has been emptied, resulting in a residual volume

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3.1.8
correction factor
numerical factor by which the uncorrected result of a measurement at the measured conditions is multiplied

Note 1 to entry: Correction factors to standard conditions are used to convert a volume at observed conditions to the volume at another (standard) condition.

3.1.9
plunger
displacement plunger
device consisting of a piston which is used for adjusting the volume of a volumetric measure

3.1.10
drain time
total time taken to empty the measure or tank to leave a consistent residual volume

Note 1 to entry: Drain time commences when the drain valve is opened and ceases when closed after a defined time or condition. Drain time may be divided into two parts: first drain time and final drain time.

Note 2 to entry: A dry measure can be employed where the product evaporates quickly, for example petrol. These measures will not have a drain time and the means to ensure they are dry will be specified in documents regulating their use.

3.1.11
final drain time
time which follows the cessation of the first drain time and finishes at a defined time, or condition, such as rate of dripping

3.1.12
first drain time
time to drain the majority of the fluid from the measure

Note 1 to entry: The first drainage flow commences when the drain valve is opened and ends at a defined level, time or when flow breaks into a defined trickle or drip rate. This is prior to the start of the final drain time.

3.1.13
dry measure
contents measure which is calibrated and used with the internal surface completely dry (i.e. no clingage or residual volume)

Note 1 to entry: The volume of a dry measure may be marked and designated to contain.

3.1.14
error
measured quantity value minus a reference quantity value

Note 1 to entry: Note1 to entry: Relative error is error divided by a reference value. This can be expressed as a percentage.

[SOURCE: VIM:2012, 2.16]

3.1.15
field measure
measure designed to be used in the regular calibration of other devices

Note 1 to entry: While most field measures are portable, some can be in a fixed location.

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3.1.16
gauge glass
clear tube in parallel with, or a window set into, the neck of a measure to show the level of liquid in the neck

Note 1 to entry: There is an associated scale to indicate the measured volume.

3.1.17
nominal volume
design volume of a volumetric measure

3.1.18
primary measure
reference measure calibrated gravimetrically

Note 1 to entry: Primary measures should be calibrated by a national measurement institute (NMI) or a competent laboratory meeting ISO/IEC 17025.

3.1.19
proving
calibration with comparison to defined acceptance criteria

Note 1 to entry: The term "proving" is used in the oil industry and is similar to verification.

Note 2 to entry: Proving is a calibration, sometimes of limited measurement range, according to methods defined by standards, regulations or procedures, providing a determination of the errors of a device and showing (proving) it performs to defined acceptance criteria.

3.1.20
proving tank
volumetric measure which generally has capacity greater than 20 l and has a bottom drain

Note 1 to entry: A prover tank can be free-standing or mounted on a truck or trailer.

3.1.21
pour
individual quantities of liquid poured from, or received into, a volumetric measure

3.1.22
range
range of values
difference between the maximum and minimum values of a set of values

Note 1 to entry: This can be expressed as a half range (±) number. Relative range is normally expressed as a percentage of a specified value, for example mean, minimum or other calculated value.

3.1.23
reference conditions
operating conditions prescribed for evaluating the performance of the measure

Note 1 to entry: This is the range of ambient and fluid conditions with which the measure is evaluated, verified or operated.

3.1.24
reference measure
volumetric measure calibrated, used and maintained to provide traceability to other volume measures and devices, including pipe provers and reference flowmeters

Note 1 to entry: A reference measure can be calibrated gravimetrically (primary measure) or volumetrically by means of a primary measure which itself has been calibrated gravimetrically.

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3.1.25
repeatability
measurement precision
closeness of agreement between indications or measured quantity values obtained by replicate measurements under specified conditions

Note 1 to entry: Specified conditions normally implies the same reference, same conditions, same operators and procedures and that the data are obtained sequentially over a short period of time.

Note 2 to entry: Repeatability can be expressed as the range (difference between the maximum and minimum) values of error or K-factor. Alternatively, repeatability can be expressed as a function of the standard deviation of the values.

Note 3 to entry: Dividing repeatability by the mean gives the relative value which can be expressed as a percentage. It is noted some standards suggest dividing by the minimum value.

[SOURCE: VIM:2012, 2.15]

3.1.26
residual volume
volume or quantity remaining in the measure after draining for the defined drain time

3.1.27
resolution
quantitative expression of the ability of an indicating device to distinguish meaningfully between closely adjacent values of the quantity indicated

3.1.28
scale datum
fixed reference point or mark, established at manufacture or initial calibration, from which subsequent adjustments to the scale can be referred

Note 1 to entry: This may be an engraved mark on the neck, or another defined fixed point such as a support bracket. The location should be referenced on calibration certificates.

3.1.29
secondary measure
volumetric measure which is calibrated by a primary measure

3.1.30
standard condition
base condition
condition of temperature and pressure to which measurements of volume or density are referred to standardize the quantity

Note 1 to entry: These are the specified values of the conditions to which the measured quantity is converted.

Note 2 to entry: For the petroleum industry, these are usually 15 °C, 20 °C or 60 °F and 101,325 kPa.

Note 3 to entry: Standard conditions can refer to the liquid or the volume of the measure. These may be different.

Note 4 to entry: Quantities of volume expressed at standard conditions may be indicated by prefixing the volume unit by "S", for example 4 Sm^3 or 700 kg/Sm^3. This abbreviation is used in place of the unit m^3 (standard conditions) where there is limited space and there is no risk of confusion regarding the unit.

Note 5 to entry: Standard conditions should not be confused with the reference (operating) conditions prescribed for evaluating the measure.

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3.1.31
standard measure
volumetric measure which is designed to meet the requirements of regulatory standards

Note 1 to entry: Examples of regulatory standards are OIML R 120, Measurement Instruments Directive (MID) and NIST 105-3.

3.1.32
standard volume
base volume
volume expressed as being at standard conditions

3.1.33
strike measure
brim measure where the volume is defined from the top edge of the neck which has been designed to be struck by sliding a ground glass disk over it to leave a consistent volume within the measure

3.1.34
test measure
hand portable volumetric measure up to 20 l capacity

Note 1 to entry: A test measure can be inverted to drain or be fitted with a bottom drain.

Note 2 to entry: A test measure can also be non-portable, in a fixed frame or on a vehicle. It may in some cases be classified as a prover tank.

3.1.35
thermowell
metal pocket which protrudes through, or is attached to, the wall of a pipe or volumetric measure to hold a temperature-measuring device

3.1.36
volume to contain
standard volume of liquid a measure contains with respect to its reference line or datum when filled from a clean dry condition

3.1.37
volume to deliver
standard volume of liquid which can be withdrawn from or filled into a pre-wetted measure with respect to its reference line or datum and following specified drainage times and procedures

Note 1 to entry: A wet condition is obtained by filling the measure and draining it for the specified drain time and procedure.

Note 2 to entry: The volume to deliver is always less than the volume to contain due to the volume of residual liquid left on the walls of the measure after the specified drain time.

Note 3 to entry: A measure marked with a volume to deliver can be used either to withdraw or to fill volumes as long as the wetting and drainage procedures are followed.

3.1.38
fill
receive
In
technique for using or calibrating a volumetric measure by filling from top or bottom with liquid from the device under test or the reference

Note 1 to entry: The reference may be volumetric or gravimetric.

Note 2 to entry: 'In' is the term adopted by EURAMET guide cg21[2].

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3.1.39
withdraw
water draw
Ex
technique for using or calibrating a volumetric measure by withdrawing liquid from the measure into the device under test or the reference

Note 1 to entry: The reference may be volumetric or gravimetric.

Note 2 to entry: 'Water draw' is usually applied to the calibration of pipe provers.

Note 3 to entry: 'Ex' is the term adopted by EURAMET guide cg21[2].

3.1.40
traceability
metrological traceability
property of a measuring result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

[SOURCE: VIM:2012, 2.41]

3.1.41
transfer point
point or location in a fluid transfer where the quantity and accountability of the fluid passes from one measurement system to another

3.1.42
uncertainty
non-negative parameter characterizing the dispersion of the quantity values attributed to a measurand based on the information used

[SOURCE: VIM:2012, 2.26]

Note 1 to entry: The uncertainty is normally expressed as a half width range along with the probability distribution with that range. It can be expressed as a value or as a percentage of the perceived true value.

3.1.43
volumetric measure
measure used to provide an accurate measure of a volume, hence providing a calibration reference for other volume-measuring devices, such as pipe displacement provers or flowmeters

3.1.44
water pour
technique for calibrating a measure by decanting liquid from a reference measure or a gravimetric system to a device under test

3.1.45
wet measure
volumetric measure which has been wetted and drained before use in accordance with defined drain times and procedures given in the calibration certificate and specification

3.1.46
wetted
portion of the internal surface of a volumetric measure which has been in contact with the liquid during use

3.1.47
weir
device, usually a horizontal edge, where a consistent liquid level is established to provide a datum

3.2 Symbols and units

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NOTE 1 The preferred unit for kinematic viscosity is metres squared per second (m^2/s) or millimetres squared per second (mm^2/s). The practical unit used in this document is the industry-recognized unit centistoke (cSt); 1 cSt = 1 mm^2/s.

NOTE 2 The preferred unit for a volume expressed at a standard condition is m^3 (standard condition). In practice this is conventionally abbreviated to Sm^3 where there is limited space and there would be no confusion of units used.

Symbol	Quantity	Unit
C_{tl}	volume correction factor for thermal expansion of liquid from measured temperature to the standard temperature	
C_{dtl}	volume correction factor for thermal expansion of liquid from reference device (measure) temperature to the temperature at the device under test	
C_{tlr}	volume correction factor for thermal expansion of liquid from reference device (measure) temperature to the standard temperature	
C_{tlt}	volume correction factor for thermal expansion of liquid from test device temperature to the standard temperature	
C_{pl}	volume correction factor for liquid compressibility from measured pressure to standard pressure	
C_{plt}	volume correction factor for liquid compressibility from pressure to standard pressure from a device under test	
C_{ts}	volume correction factor for the thermal expansion of the device (material) to volume at standard temperature	
C_{tsr}	volume correction factor for the thermal expansion of the reference measure material to the volume at standard temperature	
C_{tst}	volume correction factor for the thermal expansion of the device under test material to the volume at standard temperature	
C_{ps}	volume correction factor for the pressure expansion of the device under test to the volume at standard pressure	
F	meter factor of a flowmeter at operating temperature and pressure	
M	mass of water collected in weigh container	kg
t_r	temperature of the liquid in the reference device	°C
t_t	temperature of the liquid in the device under test	°C
t_{sr}	standard temperature for the reference measure	°C
t_{st}	standard temperature of the device under test	°C
V_m	indicated volume from a flowmeter at actual conditions	m^3 or l
V_r	volume measured by a reference, measure or flowmeter, at actual conditions of pressure and temperature	m^3 or l
V_{rs}	calibrated volume of a measure corrected for scale indication, i.e. the indicated volume, at standard conditions, from a reference measure, corrected for known calibrations errors	m^3 or l (standard conditions)
V_{ts}	volume of device under test at standard conditions	m^3 or l (standard conditions)
V_t	volume transferred to or from a reference to the device under test	m^3 or l
W_a	weight of liquid collected in the weigh container during gravimetric calibration	kg
α_r	linear expansion coefficient of the reference device	$°C^{-1}$
α_t	linear expansion coefficient of the device under test	$°C^{-1}$
ρ_a	density of air during weighing	kg/m^3
ρ_w	nominal density of weights used to calibrate weighing machines (normally defined as 8 000 kg/m^3)	kg/m^3
ρ_r	density of liquid in reference device at t_r	kg/m^3

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Symbol	Quantity	Unit
ρ_t	density of liquid in device under test at t_t	kg/m^3

4 Traceability

All the volumetric measures described have a unique hierarchy in the traceability chain. All are traceable to standards of mass combined with the derived density of pure water. There is a hierarchy for traceability which is followed to provide the uncertainty required by the final application.

A primary measure would be calibrated by weighing the water withdrawn to a tank on a weigh scale or to directly weigh the measure and determine the weight of liquid filled or withdrawn. The weigh scale is calibrated with mass standards of the required class[3] and uncertainty. The mass and the density of the water are then combined to give the volume.

A primary measure can be used to determine the volume of a secondary measure. This can require multiple measurements fills. A secondary measure can be used to determine the calibration factor of a flowmeter. This can be a reference flowmeter used to measure volume in a pipe prover or large volume measure or to calibrate other meters.

Figure 1 shows schematically a primary measure being used to determine the volume of a small volume prover, which in turn is used to calibrate a reference flowmeter used to determine the volume of a large pipe prover.

Primary and reference measures are calibrated using pure water or clean drinking water. The water density is determined from the recommended formulae relating density to temperature and corrected where required through a measurement of relative density. The water density can also be experimentally determined by the use of a calibrated densitometer.

Some secondary measures, particularly large fixed measures, may need to be calibrated with impure water, seawater or a hydrocarbon product.

Applicable liquid property formulae are given in Annex A.

The uncertainty for volume determination should be specified according to the application. Indicative values of uncertainty applicable to different volumetric measures are given in Annex E.

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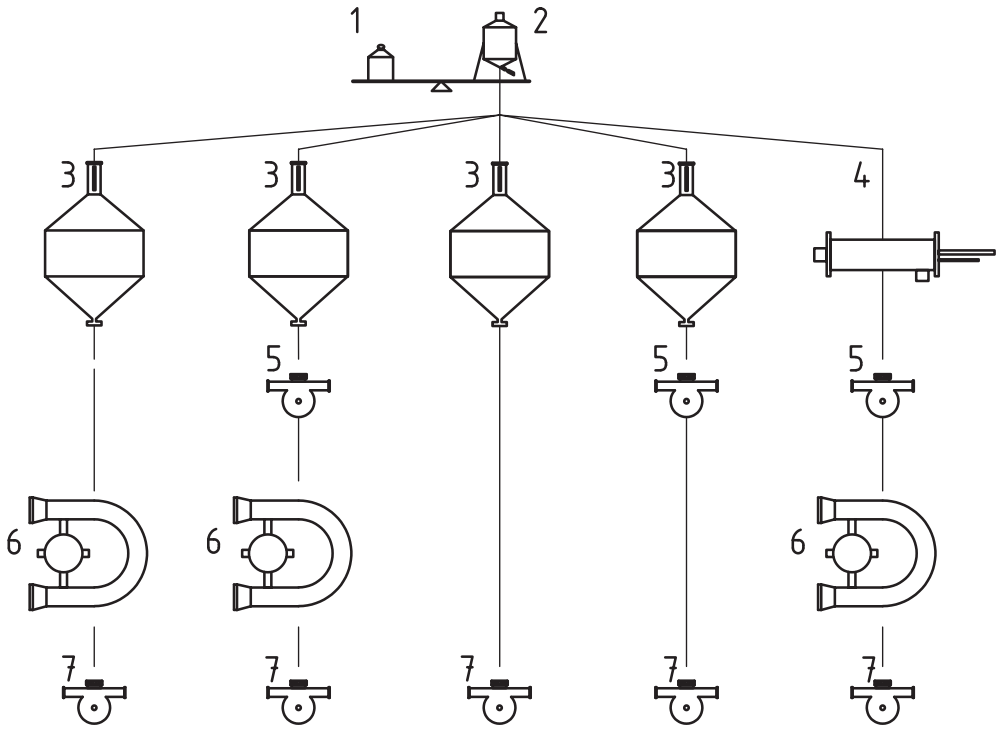

Key

1 mass standard
2 primary reference measure
3 primary measure
4 small volume piston prover
5 reference flowmeter
6 pipe prover
7 secondary measure

Figure 1 — Traceability: hierarchy of volumetric measures

5 General design characteristics of volumetric measures

5.1 General design

Volumetric measures are containers of defined internal volume. The nominal volume is derived by design and manufacture with the calibrated volume subsequently determined by calibration. The volume is defined between a top and bottom datum. The top datum can be a reference line on a scale or an overflow weir. The bottom datum can be an overflow weir, the internal plane of a drain valve (when closed) or a scale reading in a bottom sump or neck.

The volume is expressed as being the volume of liquid in the measure when it is at a defined standard condition. Nominal and calibrated volume(s) may be given for one or different standard conditions.

The volume to deliver is the standard volume of a measure which can be withdrawn from a full measure with a defined drain time. It is also the volume which can be filled into a measure which has been pre-wetted by filling then draining for the defined drain time.

The volume to contain is the standard volume of a clean dry measure. The volume to contain is always larger than the volume to deliver due to residual liquid remaining on the walls of a wet measure.

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As nominal and calibrated volumes can have different conditions, both should always be clearly identified as being to contain or to deliver and the standard temperature referenced.

Volumetric measures are classified into two categories separated by what is considered to be a safe weight for manual handling. This division follows guidance given by OIML-R120[4], NIST-105-3[5] and API-MPMS chapters 4.4[6] and 4.7[7].

1) Test measures have volumes between 5 l and 20 l. However, smaller measures including 3,8 l (1 US gallon) and measures down to 1 l, manufactured in stainless steel or carbon fibre, are also included in the classification. Test measures produced following the design, specifications and volumes defined in regulatory standards are classified as standard measures. Test measures can also be referred to as field measures when designed to be portable.

2) Proving tanks are measures with larger volumes. Proving tanks can have volumes above 20 l and extend to tanks up to 20 m^3 or above.

Volumetric measures in glass are a category of cylinders or flasks with volumes less than 10 l. These are not covered by this document but may be used as additional volume measures for use in the calibration process. Standard sizes for glass measures are shown in Annex C. Specifications for such measures are given in ISO 4788.

Measures can be top filled or bottom filled.

Drainage of test measures can be by inverting the measure and pouring out the contents or by draining through a bottom connection and valve. Proving tanks are drained from the bottom.

Volumetric measures are constructed of materials which should be resistant to corrosion by water and any other fluid which may be used, including cleaning fluids. Stainless steel is the most common material; however, other metals can be used, particularly in older measures. Carbon steel can be utilized for large secondary measures if internally protected from corrosion through coating with epoxy resin, phenolic or glass. The use of unprotected carbon steel should be avoided as it is subject to corrosion and deposition even if hydrocarbons are the only fluid to be used. A low or well-defined coefficient of expansion of the material is chosen, hence the use of materials such as aluminium and plastic is not normally acceptable (carbon fibre composite being the exception as it has a very low coefficient of expansion).

The material used needs to be documented and the coefficient of expansion given in the design documentation and calibration certificates. This should also be engraved on the marking plate where possible. Suggested default coefficients of expansion of materials are given in Annex A.

Construction and design are such that there is minimal distortion of the measure when filled or emptied. This is achieved through adequate thickness of the materials. Strengthening bands and shaped end closures provide adequate stiffness to the measure. Measures are exclusively cylindrical in shape.

The design and construction should ensure all liquid drains from the measure when it is emptied and all air is expelled when it is filled. The cylindrical section should be vertical or at a slope, with ends constructed with a domed or coned shape. Slopes on cones and cylinders should be approximately 30° to the horizontal. Standard proving tanks and test measures have specified slopes for top and bottom cones.

Internal welds and joints should be smooth and constructed to avoid retention of fluid or air. The surface finish should be smooth to minimize liquid clingage and contamination through deposition.

Any inspection flanges or joints between sections of the measure should be constructed with metal-to-metal face joints sealed with “O” rings or non-compressible gaskets to ensure no change in volume in use, or minimal change if disturbed. Similarly, any insertions into the measure such as thermowells, connections to sight tubes, windows and valves should be of welded construction or metal-to-metal faced joints and angled to avoid liquid or air entrapment.

There should be a top vertical neck section with a diameter designed to provide suitable resolution of volume measurement. In proving tanks there can also be a bottom neck.

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All measures should have means of indicating the volume through the use of a sight glass or window with a scale, or alternatively a weir, associated with the top neck. This provides the top datum to indicate the volume. A bottom datum is established at a fixed location which can be the plane of the drain valve, a weir or a level in a sight glass or window on a bottom neck.

Any valves used with a volumetric measure, for filling or draining, should be demonstrably bubble-tight on low differential pressure tests. Depending on the duty, valves used for filling should also be leak-tight at the appropriate pressure. A method for checking valve leakage in the system, usually by means of visual inspection, is required.

One practical leak-testing method is to first have the measure in a thermally stable environment. It is then filled and the level recorded, with all surfaces under the measure dried. It is then left undisturbed for a period of 1 h or more before rechecking the level has remained constant and the surrounding area shows no signs of leakage.

Valves should be sized to suit the filling and drainage flowrates required by the measure. Double block valves can be required in some locations.

It is important that the operation of the valve, particularly drain valves, has no demonstrable effect on the measured volume by displacing fluid during operation.

A means and method of providing for calibrations, including connections and valves, should be defined to allow reproduction of the original calibration conditions.

Examples of the different aspects of design are given in subsequent clauses of this document.

5.2 Design to indicate the volume — Resolution

5.2.1 Neck size

All measures rely on a means to indicate or define the volume contained when full. This can be by attaining a level at the top, a weir or overflow, or by observing the level in a window and comparing to a scale.

A measure can require a large diameter to contain the required volume but this provides a poor resolution of the level. To provide the required resolution, measures are designed to have a reduced area in the form of a vertical neck. This allows a large volume to be collected in the main body but the level in the neck to be observed to the required resolution. The narrower the neck, the higher the resolution.

While providing adequate resolution, the cross-sectional area of the neck should not provide a significant back pressure when the measure is being filled and air vented out. The neck should be long enough to allow the rising level to be observed and the flow to be stopped within the scale.

For high-accuracy laboratory test measures the neck should be relatively long and narrow; field test measures have a shorter and relatively wider neck. The neck area is the sum of the cross-sectional areas of the neck, the sight tube and any external top filling tube.

As a guide the neck diameter should be such that 3 mm change in level equates to the maximum uncertainty in volume required from the measure. For standard measures, the neck volume should be in the order of ± 1 % of the total volume of the tank. Where the filling flowrate is high, or when a high resolution is required, the neck, and any sight glass and scale, can be longer. Suggested neck diameters for standard measures are given in OIML-R120[4].

5.2.2 Gauge glass

Measures not employing a top weir should have means of indicating the volume contained. This can either be a separate sight tube in parallel with the neck or a window inserted into the neck. There should be a scale associated with the gauge glass. The gauge glass may be longer than the scale associated with it to allow observation of the level in the tank above and below the measuring section.

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Gauge glass should be manufactured from borosilicate glass unless there is an incompatibility with the fluids used.

The gauge glass scale allows reading of the level in the neck and has a scale marked or engraved legibly and indelibly on the scale. Although scale marking could be engraved on the glass, a separate scale alongside the glass is preferred. A separate scale allows better clarity when reading a meniscus and allows for adjustment.

Additional information on how to read the level when a meniscus is formed against a gauge glass is given in Annex D.

The diameter of a sight tube should be such that the desired level of resolution is achieved, taking into account the formation of a meniscus forming at the tube wall. Standard measures have recommended tube diameters given in OIML-R120[4].

Sight tubes should have a clear, unimpeded entry to allow the fluid to flow evenly into the tube without restriction. The top of the tube should vent into the top of the neck, below the top, hence allowing free venting of vapour and overflow to the neck. There can be an access to the top of the tube to allow cleaning without disturbing the tube and hence the volume of the measure.

In adverse environmental conditions, it should be ensured that sight tube temperature does not differ significantly from the tank temperature. Such a difference can introduce a volume error due to differential temperature expansion of the fluid within the tube.

In conditions of gusting wind, it can be difficult to obtain a settled level reading in the gauge glass due to pressure variations acting on the surface of the liquid in the neck of the tank. Precautions should then be taken to protect the top of the neck from the wind.

Measures can have an overflow weir to set the datum level rather than a gauge glass and scale. A weir should have similar requirements for resolution and the diameter (length) of the weir. Weir edges should be machined horizontal and the edge chamfered outward to a sharp, defined edge.

5.2.3 Scales

Examples of scales and markings are shown in Figure 2. Scales should be fitted either side of a gauge glass or window in a manner that the level can be seen and related to the scale reading in an accurate and consistent way. This should maximize clarity and minimize error due to misreading, identification of meniscus and operator interpretation. A single scale should be fitted to one side of a gauge glass tube; however, a frame design with scale marks either side is preferred. Scales should be positioned between 2 mm and 5 mm from the side of the window or tube and slightly in front.

A single scale should be positioned to ensure there is no bias in the reading while a scale with frame design and units on each side should be of one-piece construction. Scale marks should extend to the edge of the scale beside the tube or window.

Where dual scales in different units are fitted, for example marking in metric and US customary units, the right-hand scale should be the metric scale and the second scale engraved appropriately on the left-hand side. It would be normal to have a single nominal value determined at calibration on one scale with the secondary scale marked according to a predetermined conversion factor.

Scales should be clearly and indelibly marked and manufactured in materials which should not be subject to wear or corrosion. Marking or engraving should be differentiated from the scale material by a different colour.

Scales should be securely attached but may be adjustable to bring the nominal scale mark in line with the calibrated volume. The adjustment should be secure and sealed to prevent tampering.

Scales for standard measures should be marked with the nominal volume mark centred on the scale. Offsetting the nominal volume mark to allow a longer graduated scale either above or below the nominal mark is allowable for specific applications. The nominal volume mark should be extended across the whole width of the scale.

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For standard measures the scale length are normally ± 0,5 % of the tank volume. A longer scale can be required for some applications.

Scales should be clearly marked and major and minor unit markings are advised. Graduation marks should extend to the edge closest to the gauge glass.

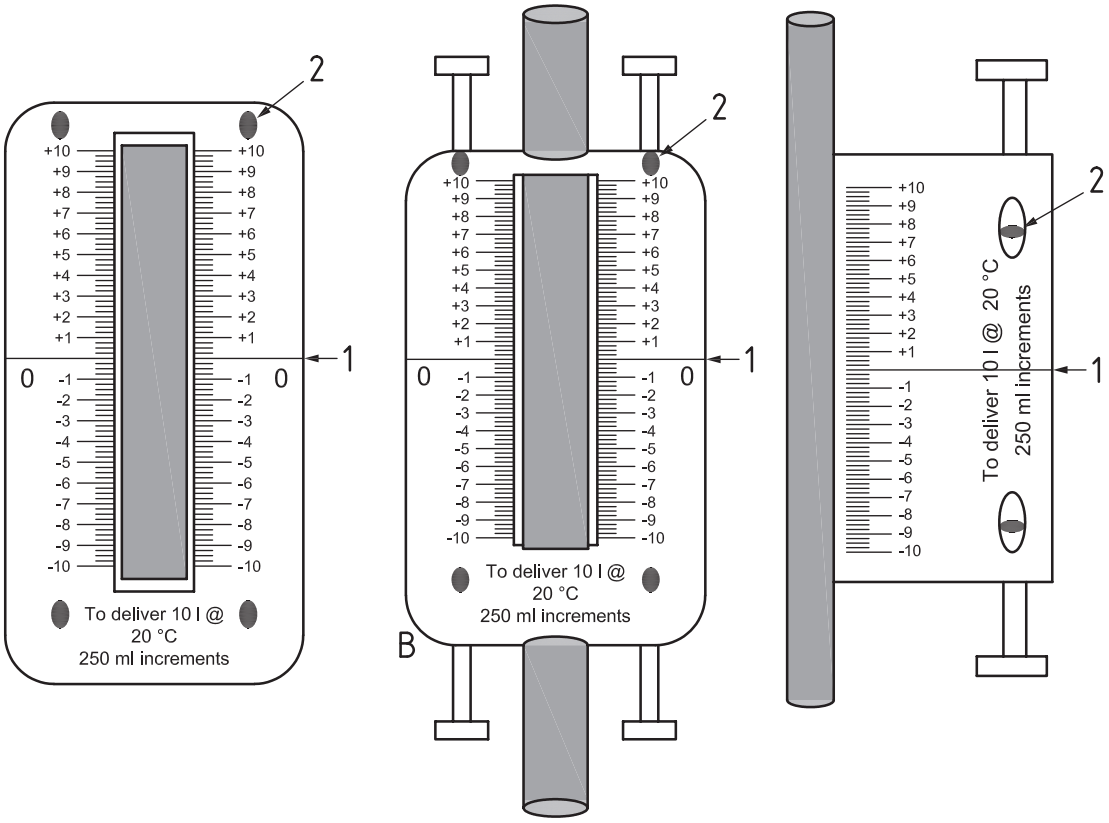
As good practice it is recommended that graduations should be spaced at 2 mm but no less than 1,5 mm apart. For standard measures, graduations should be set to indicate an increment relating to 0,05 % of the volume of the measure. For primary measures this interval should be reduced to 0,02 % and for high resolution primaries reduced further to 0,01 %.

It is important that scales are oriented to reduce the potential for parallax error when reading. Provision to allow an operator to attain a horizontal eye line at any point across the range of the scale length with safe and secure access is required.

The scale should indicate the value and units of the nominal volume and the units of increment. The value of nominal volume may be shown anywhere on the scale or against the nominal scale mark. Scale increments should be values of volume or as ± volume increments from the nominal volume. Marking as ± percentage from the nominal volume is not advised. The prime importance is clarity of scale increment markings to reduce any chance of misreading. Dual scales should show units on both sides.

The scale plate should show the nominal volume as indicating the volume to contain or volume to deliver. It is important, however, to recognize the calibrated volume could have been derived differently from the nominal volume and steps should be taken to avoid confusion.

It can also be useful to show the standard temperature on the scale in addition to showing on the marking plate.



Key

1 nominal volume mark

2 fixing screw and seal

Figure 2 — Examples of scales

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