TABLE 1

LIFE TEST REQUIREMENTS

Nominal Flow Rate	*Test Flow Rate*	*Type of Test*	*No. of Interruptions*	*Duration of Pauses*	*Period of Operation at Test*	*Duration of Start up and Run Down*
Q_n Kl/h				s		s
(1)	(2)	(3)	(4)	(5)	(6)	(7)
≤ 10	Q_n	Dis-continuous	100 000	15	15 s	$0.15(Q_n)$* with a minimum of 1 s
	$2Q_n$	Continuous	-	-	100 h	-
>10	Q_n	Continuous	-	-	800 h	-
	$2\ Q_n$	Continuous	-	-	200h	-

* Qn is the number equal to the value of Qn expressed in kl/h.

After the meters having undergone the life test, they shall again be subjected to flow tests and pressure tightness test. They shall be deemed satisfactory if their performance after the life test satisfies the above requirements.

One of the meter which has undergone the life test (preferably the one that has shown greater deterioration in its performance under the flow test) shall be dismantled completely and examined with a view to ensuring that there is no undue wear or distortion. Particular attention shall be paid during examination to the wear of the actuating unit comprising vane wheel or piston, the impeller and measuring chamber, bearings, gears and pistons, pivots and the gland packing.

PART IV

MEASURING SYSTEM FOR LIQUIDS OTHER THAN WATER

PART-1

TERMINOLOGY

1. Measuring system and its constituents

(1) Meter for volumes of liquids

An instrument intended to measure continuously, memorize and display the volume of liquid passing through the measurement transducer at metering conditions.

Note: A meter includes at least a measurement transducer, a calculator (including adjustment or correction devices if present) and an indicating device.

(2) Measurement transducer

A part of the meter which transforms the flow or the volume of the liquid to be measured into signals which are passed to the calculator. It may be autonomous or use an external power source.

Note : For the purposes of this specification, the measurement transducer includes the flow or volume sensor.

(3) Calculator

A part of the meter that receives the output signals from the transducer(s) and, possibly, from associated measuring instruments, transforms them and, if appropriate, stores in memory the results until they are used. In addition, the calculator may be capable of communicating both ways with peripheral equipment.

(4) Indicating device

A part of the meter which displays continuously the measurement results.

Note : A printing device which provides an indication at the end of the measurement is not an indicating device.

(5) Ancillary device

A device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results.

Main ancillary devices are:—

(i) zero setting device;

(ii) repeating indicating device;

(iii) printing device;

(iv) memory device;

(v) price indicating device;

(vi) totalizing indicating device;

(vii) conversion device;

(viii) pre-setting device; and

(ix) self-service device.

(6) Additional device

A part or a device, other than an ancillary device, required to ensure correct measurement or intended to facilitate the measuring operations, or which could in any way affect the measurement.

Main additional devices are:—

(i) gas elimination device;

(ii) gas indicator;

(iii) sight glass;

(iv) filter, pump;

(v) device used for the transfer point;

(vi) anti-swirl device;

(vii) branches or bypasses; and

(viii) valves, hoses.

(7) Measuring system

A system which comprises the meter itself and all the ancillary devices and additional devices.

(8) Pre-setting device

A device which permits the selection of the quantity to be measured and which automatically stops the flow of the liquid at the end of the measurement of the selected quantity.

Note : The pre-set quantity may be the volume, the mass or the related price to pay.

(9) Adjustment device

A device incorporated in the meter, that only allows shifting of the error curve generally parallel to itself, with a view to bringing errors within the maximum permissible errors.

(10) Associated measuring instruments

Instruments connected to the calculator, the correction device or the conversion device, for measuring certain quantities which are characteristics of the liquid, with a view to making a correction or a conversion or both.

(11) Correction device

(i) A device connected to or incorporated in the meter for automatically correcting the volume at metering conditions, by taking into account the flowrate or the characteristics of the liquid to be measured (viscosity, temperature and pressure) and the pre-established calibration curves or both.

(ii) The characteristics of the liquid may either be measured using associated measuring instruments, or stored in a memory in the instrument.

(12) Conversion device

(i) A device which automatically converts the volume measured at metering conditions into a volume at base conditions, or into a mass, by taking account of the characteristics of the liquid (temperature, pressure, density, relative density.....) measured using associated measuring instruments, or stored in a memory.

(ii) The quotient of the volume at base conditions, or of the mass, to the volume at metering conditions is referred to as "conversion factor".

(13) Metering conditions

The conditions of the liquid of which the volume is to be measured, at the point of measurement (example: temperature and pressure of the measured liquid).

(14) Base conditions

The specified conditions to which the measured volume of liquid is converted (example: base temperature and base pressure).

Notes (i) Metering and base conditions (which refer only to the volume of liquid to be measured or indicated) should not be confused with the "rated operating conditions" and "reference conditions" which apply to influence quantities.

(ii) The values chosen as base conditions should preferably be 15°C or 20°C, and 101 325 Pa.

(15) Transfer point

A point at which the liquid is defined as being delivered or received.

(16) Gas separator

A device used for continuously separating, and removing, any air or gases contained in the liquid.

Note : In general, devices defined from paragraphs 1(16) to 1(19) are called gas elimination devices.

(17) Gas extractor

A device used to extract air or gases accumulated in the supply line of the meter in the form of pockets that are no more than slightly mixed with the liquid.

(18) Special gas extractor

A device which, like the gas separator but under less stringent operating conditions, continuously separates any air or gases contained in the liquid, and which automatically stops the flow of liquid if there is a risk of air or gases, accumulated in the form of pockets no more than slightly mixed with the liquid, entering the meter.

(19) Condenser tank

In pressurized liquefied gas measuring systems, a closed tank used to collect the gases contained in the liquid to be measured and to condense them before measuring.

(20) Gas indicator

A device allowing easy detection of any air or gas bubbles which may be present in the liquid flow.

(21) Sight glass

A device for checking, before start-up and after shut-down, that all or part of the measuring system is filled completely with liquid.

2. Specific types of measuring systems

(1) Fuel dispenser

A measuring system intended for the refuelling of motor vehicles, small boats and small aircraft.

(2) Measuring system on a pipeline

A measuring system which in principle is installed on a fixed pipeline connecting two or more fixed tanks.

Note : This pipeline is characterized by a flowrate of the liquid to be measured which, in general, either does not change or changes little during a prolonged period.

(3) Aircraft refuelling tanker measuring system

A tanker mounted measuring system intended for refuelling aircraft, supplied from a tank mounted on the vehicle.

(4) Aircraft hydrant measuring system

A mobile measuring system intended for refuelling aircraft, supplied from hydrant pits.

(5) Blend dispenser

A fuel dispenser providing mixtures of various grades of gasoline (multigrade-dispenser) or mixtures of gasoline and lubricating oil (gasoline-oil-dispenser) through a single nozzle.

(6) Self-service arrangement

An arrangement that allows the customer to use a measuring system for the purpose of obtaining liquid for his own purchase.

(7) Self-service device

A specific device that is part of a self-service arrangement and which allows one or more measuring systems to perform in this self-service arrangement.

Note : The self-service device includes all the elements and constituents that are mandatory so that a measuring system performs in a self-service arrangement.

(8) Attended service mode

An operating mode of a self-service arrangement in which the supplier is present and controls the authorization for the delivery.

Notes : (i) In attended service mode, the settlement of the transaction takes place before the customer leaves the site of the delivery.

(ii) A transaction is settled when the parties interested in the transaction have made their agreement known (explicitly or implicitly) as regards the amount of the transaction. This may be a payment, signing a credit card voucher, signing a delivery order, etc.

(iii) The parties interested in a transaction may be the parties

themselves or their representatives (for example: the employee in a filling station, the driver of a truck).

(iv) In attended service mode the measurement operation ends at the moment settlement of the transaction takes place.

(9) Unattended service mode

An operating mode of a self-service arrangement in which the self-service arrangement controls the authorization for the delivery, based on an action of the customer.

Note : In unattended service mode, the end of the measurement operation is the end of the registration (printing or memorizing) of information concerning the measurement operation.

(10) Pre-payment

A type of payment in attended or unattended service mode requiring payment for a quantity of liquid before the delivery commences.

(11) Attended post-payment (or post-payment)

A type of payment in attended service mode requiring payment for the delivered quantity after the delivery but before the customer leaves the site of the delivery.

(12) Unattended post-payment (or delayed payment)

A type of payment in unattended service mode in which payment for the delivered quantity is required after the delivery, but in which the transaction is not settled when the customer leaves the site, following an implicit agreement with the supplier.

(13) Authorization of a measuring system

An operation that brings the measuring system into a condition suitable for the commencement of the delivery.

(14) Direct selling to the public

A transaction (selling or buying) of quantities of liquids whose settlement is associated with indications provided by a measuring system, any of the parties having access to the place of measurement and one of them being a consumer.

Notes : (i) The consumer can be any person. Generally the consumer is the buyer but he can also be the seller.

(ii) Main measuring systems used for direct selling to the public are :

- fuel dispensers,
- measuring systems on road tankers for the transport and delivery of domestic fuel oil.

3. Metrological characteristics

(1) Primary indication

An indication (displayed, printed or memorized) which is subject to legal metrology control.

Note : Indications other than primary indications are commonly referred to as secondary indications.

(2) Absolute error of measurement

The result of a measurement minus the (conventional) true value of the measurand.

(3) Relative error

The absolute error of measurement divided by the (conventional) true value of the measurand.

(4) Maximum permissible errors

The extreme values permitted by the specification for an error.

Notes : (i) Maximum permissible errors are stated as relative errors or absolute errors.

(ii) Where the comparison of a volume (for instance: difference between a result obtained at some specified conditions and a result obtained at reference conditions) with maximum permissible error is involved then, it is obvious that it is the absolute maximum permissible error, associated with the relative maximum permissible error, which applies.

(5) Minimum measured quantity of a measuring system

The smallest volume of liquid for which the measurement is metrologically acceptable for that system.

(6) Minimum specified volume deviation

The absolute value of the maximum permissible error for the minimum measured quantity of a measuring system.

(7) Minimum specified price deviation

The price to pay corresponding to the minimum specified volume deviation.

(8) Repeatability error

For the purposes of this Recommendation, the difference between the largest and the smallest results of successive measurements of the same quantity carried out under the same conditions.

(9) Intrinsic error

The error of a measuring system used under reference conditions.

(10) Initial intrinsic error

The intrinsic error of a measuring system as determined prior to all performance tests.

(11) Fault

The difference between the error of indication and the intrinsic error of a measuring system.

(12) Significant fault

A fault the magnitude of which is greater than the larger of these two values:—

(i) one-fifth of the magnitude of the maximum permissible error for the measured volume;

(ii) the minimum specified volume deviation.

The following are not considered to be significant faults, namely:—

(i) faults arising from simultaneous and mutually independent causes in the measuring instrument itself or in its checking facilities;

(ii) transitory faults being momentary variations in the indication, which cannot be interpreted, memorized or transmitted as a measurement result; and

(iii) faults implying the impossibility of performing any measurement.

(13) Durability

The capability of the measuring system to keep its performance characteristics over a period of use.

(14) Interruptible or non-interruptible measuring system

A measuring system is considered as interruptible or non-interruptible respectively when the liquid flow can or, as the case may be, cannot be stopped easily and rapidly.

(15) Cyclic volume

The volume of liquid corresponding to the working cycle of the measurement transducer, i.e. the sequence of movements at the end of which all the internal moving parts of this transducer return, for the first time, to their initial positions.

(16) Periodic variation

The maximum difference, during one working cycle, between the volume produced by the displacement of the measuring parts and the corresponding volume as shown by the indicating device, the latter being connected without play or slip to the measuring device and in such a way that it indicates at the end of the cycle, and for this cycle, a volume equal to the cyclic volume; this variation may be reduced in some cases by the incorporation of a suitable correction device.

Note : The effect of the correction device is included when the periodic variation is determined.

(17) First element of an indicating device

Element which, in an indicating device comprising several elements, carries the graduated scale with the smallest scale interval.

4. Test conditions

(1) Influence quantity

A quantity which is not the subject of the measurement but which influences the value of the measurand or the indication of the measuring system.

(2) Influence factor

An influence quantity having a value within the rated operating conditions of the measuring system, as specified in this specification.

(3) Disturbance

An influence quantity having a value within the limits specified but outside the specified rated operating conditions of the measuring system.

Note : An influence quantity is a disturbance if for that influence quantity the rated operating conditions are not specified.

(4) Rated operating conditions

Conditions of use, giving the range of values of influence quantities for which the

metrological characteristics are intended to be within the maximum permissible errors.

(5) Reference conditions

A set of specified values of influence factors fixed to ensure valid inter-comparison of results of measurements.

(6) Performance test

A test intended to verify whether the measuring system under test (Equipment Under Test) is capable of accomplishing its intended functions.

(7) Endurance test

A test intended to verify whether the meter or the measuring system is able to maintain its performance characteristics over a period of use.

(8) Uncertainty of the determination of an error

An estimate characterizing the range of values within which the true value of an error lies, including components due to the standard and its use, and components due to the verified or calibrated instrument itself.

Note : Components due to a verified or calibrated meter are notably linked to the resolution of its indicating device and to the periodic variation.

5. Electronic or electrical equipment

(1) Electronic device

A device employing electronic sub-assemblies and performing a specific function. Electronic devices are usually manufactured as separate units and are capable of being tested independently.

Note : Electronic devices, as defined above, may be complete measuring systems or part of measuring systems, in particular such as those mentioned in paragraph 1(1) to 1(5).

(2) Electronic sub-assembly

A part of an electronic device, employing electronic components and having a recognizable function of its own.

(3) Electronic component

The smallest physical entity which uses electron or hole conduction in semi-conductors, gases, or in a vacuum.

(4) Checking facility

A facility which is incorporated in a measuring system and which enables significant faults to be detected and acted upon.

Note : The checking of a transmission device aims at verifying that all the information which is transmitted (and only that information) is fully received by the receiving equipment.

(5) Automatic checking facility

A checking facility operating without the intervention of an operator.

(6) Permanent automatic checking facility (type P)

An automatic checking facility operating during the entire measurement operation.

(7) Intermittent automatic checking facility (type-I)

An automatic checking facility operating at least once, either at the beginning or at the end of each measurement operation.

(8) Non-automatic checking facility (type N)

A checking facility which requires the intervention of an operator.

(9) Power supply device

A device which provides the electronic devices with the required electrical energy, using one or several sources of a.c. or d.c.

PART-2

MEASURING SYSTEM FOR LIQUIDS OTHER THAN WATER

1. Field of application

(1) Scope

This Specification provides the metrological and technical requirements applicable to dynamic measuring systems for quantities 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.).

In principle, this Specification applies to all measuring systems fitted with a meter as defined under paragraph 1(1) of Part 1-Terminology (continuous measurement), whatever be the measuring principle of the meters or their application, except—

(i) drum meters for alcohol;

(ii) measuring systems for cryogenic liquids;

(iii) direct mass measuring systems,

the provisions of paragraph 4 shall

apply to electronic measuring systems for alcohol and for cryogenic liquids. This Specification also applies to systems in which volume measurements are converted to mass indication.

Moreover, specific provisions could be developed for measuring systems equipped with e.g. ultrasonic or vortex meters. It will then be appropriate to decide whether such meters should be included in the scope of this Specification.

This Specification is not intended to prevent the development of new technologies.

(2) Liquids to be measured

Measuring systems that are covered by this Specification may be used for the following liquids, namely :—

(i) *liquid petroleum and related products* : crude oil, liquid hydrocarbons, liquefied petroleum gas (LPG), liquid fuel, lubricants, industrial oils, etc.;

(ii) *liquid food* : dairy products (milk, cream, etc.), beer and brewer's worth, wine and musts (cider, etc.), alcoholic beverages (liquor, whisky, etc.) non-alcoholic carbonated and not carbonated beverages, juices and concentrates, vegetable oils (Soya-bean-oil, palm-oil, etc.);

(iii) *alcohol* : pure ethanol (ethyl alcohol) and mixtures of only ethanol and water (except drum meters for alcohol) ;

(iv) *chemical products in liquid state* : HCl, H_2SO_4, ammonia water etc; and

(v) *other liquids* : all other liquids except cold potable water and hot water; examples: distilled water and deionised water, liquids used for calibration of tanks.

2. General requirements

(1) Constituents of a measuring system

A meter itself is not a measuring system. The smallest possible measuring system includes—

(i) a meter,

(ii) a transfer point,

(iii) a hydraulic circuit with particular characteristics which must be taken into account,

(iv) a gas elimination device,

(v) a filter device,

(vi) a pumping device,

(vii) correction devices related to temperature, viscosity, etc.

The measuring system may be provided with other ancillary and additional devices.

If several meters are intended for a single measuring operation, the meters are considered to form a single measuring system.

If several meters intended for separate measuring operations have common elements (calculator, filter, gas elimination device, conversion devices, etc.) each meter is considered to form, with the common elements, a measuring system.

(2) Ancillary devices

(i) Ancillary devices may be a part of the calculator or of the meter, or may be peripheral equipment, connected through an interface to the calculator.

(ii) In addition these devices shall bear a legend which is clearly visible to the user to indicate that they are not controlled when they display a measurement result visible to the user. Such a legend will be present on each print out likely to be made available to the consumer.

(3) Field of operation

(i) The field of operation of a measuring system is determined by the following characteristics, namely :—

(a) minimum measured quantity,

(b) measuring range limited by the minimum flowrate, Q_{min}, and the maximum flowrate, Q_{max},

(c) maximum pressure of the liquid, P_{max},

(d) minimum pressure of the liquid P_{min},

(e) nature of the liquid(s) to be measured and the limits of kinematic or dynamic viscosity when an indication of the nature of the liquids alone is not sufficient to characterize their viscosity,

(f) maximum temperature of the liquid, T_{max},

(g) minimum temperature of the liquid, T_{min}, and

(h) environmental class.

(ii) The minimum measured quantity of a measuring system shall have the form 1×10^n, 2×10^n or 5×10^n authorized units of volume, where n is a positive or negative whole number, or zero.

The minimum measured quantity shall satisfy the conditions of use of the measuring system; except in exceptional cases, the measuring system shall not be used for measuring quantities less than this minimum measured quantity.

The minimum measured quantity of a measuring system shall be not less than the largest minimum measured quantity of any one of its constituent elements (meter(s), gas extractor(s), special gas extractor(s), etc.). However, for gas elimination devices this provision does not need to be fulfilled if it is demonstrated (including tests) that it is not necessary.

(iii) The measuring range shall satisfy the conditions of use of the measuring system; the latter shall be designed so that the flowrate is between the minimum flowrate and the maximum flowrate, except at the beginning and at the end of the measurement or during interruptions.

The measuring range of a measuring system shall be within the measuring range of each of its elements.

Except in the case of specific provisions of certain types of measuring systems, the maximum flowrate of the measuring system shall normally be equal to at least four times the minimum flowrate of the meter or the sum of the minimum flowrates of the meters with which it is fitted. In some particular cases the ratio may be two.

(iv) A measuring system shall exclusively be used for measuring liquids having characteristics within its field of operation, as specified in the pattern approval certificate. The field of operation of a measuring system shall be within the fields of measurement of each of its constituent elements (metres, gas elimination devices).

When two or more meters are mounted in parallel in the same measuring system, the limiting flowrates (Q_{max}, Q_{min}) of the various metres are taken into consideration, especially the sum of the limiting flowrates, to verify if the measuring system meets the provision above.

(4) Accuracy classes

Taking into consideration their field of application, measuring systems are classified into four accuracy classes according to Table 1.

TABLE 1

Class	*Field of application*
0.3	Measuring systems on pipeline [see paragraph 5.(6)]
	All measuring systems if not differently stated elsewhere in this table, in particular:
	• fuel dispensers for motor vehicles (other than LPG dispensers) [see paragraph 5.(1) and 5.(9)]
0.5	• measuring systems on road tankers for liquids of low viscosity [see paragraph 5.(2)]
	• measuring systems for the unloading of ships' tanks and rail and road tankers [see paragraph 5.(3)]
	• measuring systems for milk [see paragraph 5.(5)]
	• measuring systems for loading ships (see paragraph 5.(6))
	• measuring systems for refuelling aircraft [see paragraph 5.(8)].
1.0	Measuring systems (other than LPG dispensers) for liquefied gases under pressure measured at a temperature equal to or above - 10°C [see paragraph 5.(4)]

- LPG dispensers for motor vehicles [see paragraph 5.(7)]
- Measuring systems normally in class 0.3 or 0.5 but used for liquids:
- whose temperature is less than - 10°C or greater than 50°C, or
- whose dynamic viscosity is higher than 1000 MPa.s, or
- whose maximum volumetric flowrate is not higher than 20 L/h

1.5 Measuring systems for liquefied carbon dioxide [Paragraph 5(4)(x)]

- Measuring systems (other than LPG dispenser) for liquefied gases under pressure measured at a temperature below - 10°C [Paragraph 5(4)]

(5) Maximum permissible errors

(i) For volumes not smaller than two litres, and without prejudice to paragraph 2(5)(iii) the maximum permissible relative errors, positive or negative, on volume indications are specified in Table 2.

TABLE 2

Accuracy classes

	0.3	0.5	1.0	1.5
A	0.3%	0.5%	1.0%	1.5%
B	0.2%	0.3%	0.6%	1.0%

(ii) For volumes smaller than two litres, and without prejudice to paragraph 2.(5)(iii), the maximum permissible errors, positive or negative, on volume indications are specified in Table 3.

TABLE 3

Measured quantity	*Maximum permissible errors*
From 1 to 2 L	· Value fixed in Table 2, applied to 2 L
From 0.4 to 1 L	· Twice the value fixed in Table 2
0.2 to 0.4 L	· twice the value fixed in Table 2, applied to 0.4 L
From 0.1 to 0.2 L	· quadruple the value fixed in Table 2
Less than 0.1 L	· quadruple the value fixed in Table 2, applied to 0.1 L

(iii) However, whatever the measured quantity may be, the magnitude of the maximum permissible error is given by the greater of the following two values:

(a) absolute value of the maximum permissible error given in Table 2 or Table 3,

(b) minimum specified volume deviation.

For minimum measured quantities greater than or equal to two litres, the minimum specified volume deviation (E_{min}) is given by the formula:

$$E_{min} = (2\ V_{min}) \times (A/100)$$

where

V_{min} is the minimum measured quantity,

A is the numerical value specified in line A of Table 2 for the relevant accuracy class.

For minimum measured quantities less than two litres, the minimum specified volume deviation is twice the value specified in Table 3, and related to line A of Table 2.

Note : The minimum specified volume deviation is an absolute maximum permissible error.

(6) Conditions for applying maximum permissible errors

Provisions in this sub-clause apply to volume indications at metering conditions [see Paragraph 2(7) for converted indications].

(i) Maximum permissible errors in line A of Table 2 apply to complete measuring systems, for all liquids, all temperatures and all pressures of the liquids, and all flowrates for which the system is intended to be, or has been approved, without any adjustment between the various tests, for:

(a) pattern approval,

(b) initial verification in one stage or the second stage of a two-stage initial verification,

(c) subsequent verifications.

(ii) *Explanation* : An adjustment is allowed for each liquid, but in this case the pattern approval certificate provides information on

the capability of the meter to measure all the liquids without particular precautions. For example, the meter may be allowed only for measuring one liquid in normal use, or an automatic device that provides an adaptation to each liquid may be necessary.

(iii) When stated in the pattern approval certificate, a one-stage initial verification or the second stage of a two-stage initial verification of a measuring system intended to measure two or more liquids may be carried out with one liquid only or with a liquid different from the intended liquids. In this case and if necessary, the pattern approval certificate provides a smaller range or a shift for maximum permissible errors, so that Paragraph 2(6)(i) is fulfilled by the measuring system for all intended liquids.

When stated in the pattern approval certificate, the initial verification of a meter of a measuring system intended to measure two or more liquids may be carried out with one liquid only or with a liquid different from the intended liquids. In this case and if necessary, the pattern approval certificate provides a smaller range or a shift for maximum permissible errors, so that Paragraph 2(6)(ii) is fulfilled by the meter for all intended liquids.

The above considerations may be extended to the case of a measuring system or a meter intended to measure only one liquid but verified with another liquid.

(7) Provisions for converted indications

(i) Maximum permissible errors on conversion devices

When a conversion device for converting into a volume at base conditions or into a mass (including all its components and associated measuring instruments) is verified separately, maximum permissible errors on converted indications due to the conversion device, positive or negative, are equal to $\pm$ (A - B), A and B being the values specified in Table 2. However, the magnitude of the maximum permissible error shall not be less than the greater of the two following values:—

(a) one-half scale interval of the indicating device for converted indications,

(b) half of the value corresponding to the minimum specified volume deviation.

(ii) Accuracy of associated measuring instruments

When verified separately, associated measuring instruments shall exhibit an accuracy at least as good as the values in Table 4.

These values apply to the indications of associated measuring instruments taken into account for the calculation of the converted quantity (they include errors mentioned in Paragraph 2(7)(iii).

TABLE 4

Maximum permissible errors on measuring	*Accuracy classes of the measuring system* 0.3	0.5	1.0	1.5
Temperature	$\pm$0.3°C	$\pm$0.5°C	$\pm$0.5°C	$\pm$0.5°C
Pressure	less than 1 MPa : $\pm$ 50 kPa between 1 and 4 MPa : $\pm$ 5% more than 4MPa: $\pm$ 200 kPa			
Density	$\pm$ 1 kg/m^3	$\pm$ 1 kg/m^3	$\pm$2 kg/m^3	$\pm$2 kg/m^3

Density

(iii) Accuracy for calculation of characteristic quantities of the liquid

When the calculating function of a conversion device is verified separately, the maximum permissible error for the calculation of each characteristic quantity of the liquid, positive or negative, is equal to two-fifths of the value fixed in paragraph 2(7)(ii). However, the magnitude of the maximum permissible error shall not be less than one-half scale interval of the indicating device for converted indications.

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(iv) Direct verification of a converted mass indication

When a conversion device is only associated with (or included in) a meter and when the converted mass indication is verified directly by comparison to mass standards (e.g. using a weighing machine) the maximum permissible errors (MPE) on the converted indication, positive or negative, are given by the formula:

$$MPE = \pm [B^2 + (A - B)^2]^{1/2}$$

where A and B are the values specified in Table 2.

When a conversion device is included in a measuring system, maximum permissible errors of line A of Table 2 apply to the converted mass indication. However, in any case, the magnitude of maximum permissible errors shall not be less than the mass corresponding to the minimum specified volume deviation.

(v) Direct verification of a converted volume indication

Standards delivering directly the true value of converted volume indications are not available for general uses. Such standards only exist for a given liquid or for very similar liquids. When such standards are available, provisions in paragraph 2(7)(iv) can be applied by analogy.

(8) Maximum permissible errors on calculators

Maximum permissible errors on quantities of liquid indications applicable to calculators, positive or negative, when they are tested separately, are equal to one-tenth of the maximum permissible error defined in line A of Table 2. However, the magnitude of the maximum permissible error shall not be less than one-half scale interval of the measuring system in which the calculator is intended to be included.

(9) Indications

(i) The volume indication shall be made in cubic centimetres or millilitres, in cubic decimetres or litres, or in cubic metres. The symbol or the name of the unit shall appear in the immediate vicinity of the indication.

Mass may only be indicated in tonnes, kilograms or grams. The symbol or the name of the unit shall appear in the immediate vicinity of the indication.

(ii) Measuring systems shall be provided with an indicating device giving the volume of liquid measured at metering conditions.

Without prejudice to the provisions in paragraph 2(9)(iii) when a measuring system is fitted with a conversion device, it shall be fitted (in addition to the device indicating volumes at metering conditions) with a device indicating the volume at base conditions or the mass.

Provisions applicable to devices which indicate the volume at metering conditions apply to devices which indicate the volume at base conditions and by analogy to devices which indicate the mass.

(iii) The use of the same display for the indications of volume at metering conditions and of volume at base conditions or of mass is authorized provided that the nature of the displayed quantity is clear and that these indications are available on request.

(iv) A measuring system may have several devices indicating the same quantity. Each shall meet the requirements of this specification. The scale intervals of the various indications may be different.

(v) For any measured quantity relating to the same measurement, the indications provided by various devices shall not deviate one from another by more than one scale interval or the greatest of the two scale intervals if they differ, except otherwise provided in clause 5 (see paragraph 5 (10)(i)(c)).

(vi) Subject to specific provisions for certain types of measuring systems, use of the same indicating device for the indications of several measuring systems (which then have a common indicating device) is authorized provided that one of the following conditions is met:—

(a) it is impossible to use any two of these measuring systems simultaneously,

(b) the indications relating to a given measuring system are accompanied by a clear identification of that measuring system and the user may obtain the indication corresponding to any of the measuring systems concerned, using a simple command.

(10) Elimination of air or gases

(i) General requirements

Measuring systems shall be constructed and installed so that during normal operation, neither air intake nor gas release will occur in the liquid upstream of the meter. If there is a risk that this requirement may not be met, the measuring systems shall incorporate a gas elimination device permitting the proper elimination of any air or undissolved gases which may be contained in the liquid before it enters the meter.

The gas elimination device shall be suitable for the supply conditions and be arranged in such a way that the effect due to the influence of the air or gases on the measuring result does not exceed—

(a) 0.5% of the quantity measured for liquids other than potable liquids and for liquids of a viscosity not exceeding 1 MPa.s,

(b) 1% of the quantity measured for potable liquids and for liquids of a viscosity exceeding 1 MPa.s.

However, it is not necessary for this effect to be less than 1% of the minimum measured quantity.

The values specified in this paragraph apply to the gas elimination device when it is subject to separate control, e.g. for pattern approval.

In this case, they apply to the differences between:

* the meter errors with air intake or with gas, and

* the meter errors without air intake or gas.

(ii) Pumped flow

A gas separator shall be provided when, subject to the provisions in paragraph 2(10) (iv), the pressure at the pump inlet may, even momentarily, fall below either the atmospheric pressure or the saturated vapour pressure of the liquid.

No gas elimination device is required when the pressure at the pump inlet is always greater than the atmospheric pressure and the saturated vapour pressure of the liquid, and if any gaseous formation liable to have a specific effect greater than 1% of the minimum measured quantity cannot form or enter the inlet pipe work of the meter, whatever be the conditions of use.

A gas elimination device is required when the pressure at the pump inlet is always greater than the atmospheric pressure and the saturated vapour pressure of the liquid, but gaseous formations liable to have a specific effect greater than 1% of the minimum measured quantity can occur. When applying this provision, it is necessary to consider, in particular—

(a) gaseous formations likely to occur owing to thermal contraction during shutdown periods; if gaseous formation is possible, a gas extractor is required.

(b) air pockets likely to be introduced into the pipework when the supply tank is completely empty; in case there is a possibility of gaseous formation, a special gas extractor is required.

The gas elimination device shall be installed downstream of the pump or be combined with the pump.

If the gas elimination device is installed below the level of the meter, a non-return valve fitted, if necessary, with a pressure limiting device shall be incorporated to prevent the pipework between the two components from emptying.

The loss of pressure caused by the flow of liquid between the gas elimination device and the meter shall be as small as possible.

If the pipework upstream of the meter incorporates several high points, it may be necessary to provide one or

more automatic or manual evacuation devices.

(iii) Non-pumped flow

When a meter is supplied by gravity without use of a pump, and if the pressure of the liquid in all parts of the pipework upstream of the meter and in the meter itself is greater than the saturated vapour pressure of the liquid and the atmospheric pressure at measuring conditions, a gas elimination device is not necessary. However, after the measuring system has been put into service, an arrangement is required to ensure that it remains correctly filled.

If the pressure of the liquid is likely to be lower than the atmospheric pressure while remaining greater than the saturated vapour pressure, an appropriate device shall prevent entry of air into the meter.

If a meter is supplied under gas pressure, the measuring system shall be so constructed that separation of air or gas is avoided. An appropriate device shall prevent entry of gas into the meter.

In all circumstances, the pressure of the liquid between the meter and the transfer point shall be greater than the saturated vapour pressure of the liquid.

(iv) Viscous liquids

Since the effectiveness of gas separators and gas extractors decreases as the viscosity of the liquids increases, these devices may be dispensed with for liquids with a dynamic viscosity of more than 20 mPa.s at 20°C.

In this case, it is necessary to make provisions to prevent entry of air. The pump shall be so arranged that the inlet pressure is always greater than the atmospheric pressure.

If it is not always possible to meet this condition, a device shall be provided to stop the flow of liquid automatically as soon as the inlet pressure falls below the atmospheric pressure. A pressure gauge shall be used to monitor this pressure. These provisions are not necessary if devices are provided which ensure that no air can enter through the joints in the sections of the pipework under reduced pressure and if the measuring system is so arranged that no air or dissolved gases will be released.

(v) Removal of gases

The gas removal pipe of a gas elimination device shall not include a manually controlled valve if closure of this valve prevents the operation of the gas elimination device. However, if such a closing element is required for safety reasons, it shall be possible to ensure by means of a sealing device that it remains in the open position, unless closure of the valve automatically prevents further measurement.

(vi) Anti-swirl device

If the supply tank of a measuring system is normally to be completely emptied, the outlet of the tank shall be fitted with an anti-swirl device, unless the measuring system incorporates a gas separator.

(vii) General provisions for gas elimination devices

(a) In principle, the gas separated in a gas elimination device is evacuated automatically. However, the automatic operation is not necessary if a device is provided which automatically either stops or sufficiently reduces the flow of liquid when there is a risk of air or gases entering the meter. In the case of shutdown, no measurement shall be possible unless the air or gases are automatically or manually eliminated.

(b) The operational limits of a gas elimination device are as follows:—

(aa) the maximum flowrate(s) for one or more specified liquids,

(bb) the maximum pressure (with no flow running) and minimum pressure (with liquid and without air intake while the pump is running at maximum flowrate) compatible with the correct operation of the gas elimination device,

(cc) the minimum measured quantity for which it is designed.

(viii) Special provisions applicable to gas separators

(a) Within the error limits specified in paragraph 2(10)(i), a gas separator fitted in a measuring system that does not incorporate a gas indicator as specified in paragraph 2(11) shall ensure the elimination of air or gases mixed with the liquid to be measured under the following test conditions :—

(aa) without air or gases the measuring system operates at the maximum flow rate and at the minimum pressure specified for the gas separator,

(bb) then air is introduced or gases are created as long as the measuring system operates. Any proportion by volume of air or gases relative to the liquid is permitted if the gas separator is designed for a maximum flowrate lower than or equal to 20 m^3/h; it is limited to 30% if the gas separator is designed for a maximum flowrate higher than 20 m^3/h (the volumes of air or gases are measured at atmospheric pressure in determining their percentages). The percentage is considered only when the meter is running.

Furthermore, when provided, the automatic gas removal device must continue to operate correctly at the maximum pressure fixed for these gas separators.

(b) Within the error limits specified in paragraph 2(10)(i), a gas separator fitted in a measuring system that incorporates a gas indicator shall ensure the elimination of air or gases mixed with the liquid to be measured under the following conditions :

(aa) without air or gases the measuring system operates at the maximum flowrate and at the minimum pressure specified for the measuring system,

(bb) then air is introduced or gases are created as long as the measuring system operates. The proportion by volume of air or gases relative to the liquid does not exceed—

... 20% for liquids of a viscosity not exceeding 1 MPa.s, other than potable liquids,

... 10% for potable liquids and for liquids of a viscosity exceeding 1 MPa.s.

The percentages are considered only when the meter is running.

When the proportion by volume of air or gases relative to the liquid is greater than the abovementioned percentages and when the gas separator does not meet the requirements with respect to the maximum permissible errors, the gas indicator must clearly reveal the presence of air or gas bubbles.

(ix) Special provisions applicable to gas extractors

A gas extractor or special gas extractor shall, at the maximum flowrate of the measuring system, ensure that elimination of an air or gas pocket of a volume (measured at atmospheric pressure) at least equal to the minimum measured quantity with no resulting additional effect greater than 1% of the minimum measured quantity.

Moreover, a special gas extractor shall also be capable of separating continuously a volume of air or gas mixed with the liquid equal to 5% of the volume of liquid delivered at the maximum flowrate without the resulting additional effect exceeding the limits fixed in paragraph 2(10)(i).

Notes :

(i) A special gas extractor is used mainly in measuring systems mounted on road tankers.

(ii) Installing a special gas extractor is subject to feeding conditions. Therefore, no performance is required for proportions greater than 5%.

(11) Gas indicator

The gas indicator shall be designed so as to provide a satisfactory indication of the presence of air or gases in the liquid.

The gas indicator shall be installed downstream of the meter. In empty hose measuring systems, the gas indicator may be in the form of a weir-type sight glass and may also be used as the transfer point.

The gas indicator may be fitted with a bleed screw or with any other venting device when it forms

a high point of the pipe work. No pipe must be connected to the venting device. Flow indicating devices (e.g. spinners) may be incorporated in gas indicators provided that such devices do not prevent observation of any gaseous formations which could be present in the liquid.

(12) Transfer point

(i) Measuring systems shall incorporate a transfer point. This transfer point is located downstream of the meter in delivery systems and upstream of the meter in receiving systems.

(ii) Measuring systems may be of two types: "empty hose" systems and "full hose" systems: the term "hose" includes rigid pipe work.

(a) Empty hose systems are, in the case of delivery equipment, measuring systems in which the transfer point is located upstream of the delivery hose. This transfer point may be in the form of either a weir type sight glass, or a closing device combined, in each case, with a system which ensures the emptying of the delivery hose after each measuring operation.

(b) Full hose systems, in the case of delivery equipment, are measuring systems in which the transfer point consists of a closing device located in the delivery line. When the delivery line has a free end, the closing device must be installed as close as possible to this end.

(c) In the case of receiving equipment, the same provisions apply by analogy to the reception pipe work upstream of the meter.

(13) Complete filling of the measuring system

(i) The meter and the pipe work between the meter and the transfer point shall be kept full of liquid during measurement and during shutdown periods.

When this condition is not met, especially in the case of permanent installations, the complete filling of the measuring system up to the transfer point shall be effected manually and monitored during measurement and shutdowns. To ensure complete elimination of air and gases from the measuring system, venting devices fitted with small sight glasses whenever possible shall be placed in appropriate positions.

(ii) The additional effect of the pipe work between the meter and the transfer point shall not be greater than 1% of the minimum measured quantity due to variations in temperature, equal to—

- 10°C for exposed pipes,
- 2°C for insulated or underground pipes.

To calculate this additional effect the coefficient of thermal expansion for the liquid shall be rounded to 1.10^{-3} per degree Celsius.

(iii) Subject to the provisions in paragraph 2(10)(iii), a pressure maintaining device shall, if necessary, be installed downstream of the meter to ensure that the pressure in the gas elimination device and in the meter is always greater than both the atmospheric pressure and the saturated vapour pressure of the liquid.

(iv) A measuring system in which the liquid could flow in the opposite direction to that of normal flow when the pump is stopped shall be provided with a non-return valve, fitted with a pressure limiting device, if necessary, when reversal of the flow could result in errors greater than the minimum specified volume deviation.

(v) In empty hose measuring systems, the pipework downstream of the meter and, if necessary, the pipework upstream of the meter shall have a high point so that all parts of the measuring system always remain full.

(vi) In full hose measuring systems which are used for measuring liquids other than liquefied gases, the free end of the hose shall incorporate a device which prevents the draining of the hose during shutdown periods.

When a closing device is installed downstream of this device, the volume of the space between them shall be as small as possible and, in all cases, be less than the minimum specified volume deviation.

(vii) If the hose comprises several components, these shall be assembled either by means of a special connector which keeps the hose

full, or by a connection system which is either sealed or requires the use of a special tool to be disconnected.

(14) Draining

(i) In empty hose measuring systems, draining of the delivery hose referred to in paragraph 2(12)(ii)(a) is ensured by a venting valve. In some cases, this valve may be replaced by special devices, e.g. an auxiliary pump or a compressed gas injector.

In measuring systems intended for minimum measured quantities of less than 10 m^3, these draining devices shall operate automatically.

However, when it is not possible, for duly established technical or safety reasons, to deliver (or to receive) the measured volume contained in hoses of an empty hose measuring system (for example, when measuring liquefied carbon dioxide), this volume shall be smaller than or equal to half the minimum specified volume deviation.

(ii) In full hose measuring systems, particularly those intended for measuring viscous liquids, the nozzle shall be so designed that it cannot retain a volume of liquid exceeding 0.4 times the minimum specified volume deviation.

(15) Variations in the internal volume of full hoses

For full hoses in a measuring system provided with a hose reel, the increase in internal volume due to the change from the coiled hose position when not under pressure to the uncoiled hose position when under pressure without any flow of liquid, shall not exceed twice the minimum specified volume deviation.

If the measuring system is not provided with a hose reel, the increase in internal volume shall not exceed the minimum specified volume deviation.

(16) Branches and bypasses

(i) In measuring systems intended to deliver liquids, no means shall be provided by which any measured liquid can be diverted downstream of the meter. However, two or more delivery outlets may be permanently installed and operated simultaneously or alternatively provided so that any diversion of flow to other than the intended receiving receptacle(s) cannot be readily accomplished or is readily apparent. Such means include, for example, physical barriers, visible valves or indications that make it clear which outlets are in operation, and explanatory signs, if necessary.

For measuring systems intended to receive liquids, such provisions apply by analogy.

A manually controlled outlet may be available for purging or draining the measuring system. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the measuring system.

(ii) In measuring systems which may operate either with an empty hose or with a full hose and which are equipped with flexible pipes, a non-return valve shall, if necessary, be incorporated in the rigid pipework, leading to the full hose immediately downstream from the selector valve. In addition, the selector valve shall not, in any position, permit connection of the discharge hose, operating as an empty hose to the pipework leading to the full hose.

(iii) Any connections which may be provided for bypassing the meter shall be closed by means of blanking flanges. However, if the operating requirements make such a bypass necessary, it shall be closed either by means of a closing disc or a double closing device with a monitoring valve in between. It shall be possible to ensure closure by means of seals, or there shall be an automatic monitoring of the double block-and-bleed valve in the bypass giving an alarm signal in case of leakage in this valve.

(17) Control and closing mechanisms

(i) If there is a risk that the supply conditions can overload the meter, a flow limiting device shall be provided. This device shall be installed downstream of the meter. It shall be possible to seal it.

(ii) The various positions of the controls of multi-way valves shall be easily visible and located by notches, stops or other fixing devices. Deviations from this requirement are permissible when the adjacent positions of the controls form an angle of 90° or more.

(18) Various provisions

(i) If provided, filters shall not disturb the measuring operation.

(ii) In the case of measuring liquid petroleum products, means for vapour recovery shall not influence the accuracy of measurements such that the maximum permissible error is exceeded.

(19) Markings

(i) Each measuring system, component or sub-system for which pattern approval has been granted shall bear, placed together legibly and indelibly either on the dial of the indicating device or on a special data plate, the following information :—

(a) pattern approval sign

(b) manufacturer's identification mark or trademark

(c) designation selected by the manufacturer, if appropriate

(d) serial number and year of manufacture

(e) characteristics as defined in paragraphs 2(3)(i), 3(1)(i)(a), 2(10)(vii)(b), or 3(1)(vii)(a).

(f) accuracy class, if other than 0.5.

Note : The indicated characteristics should be the actual characteristics of use, if they are known when the plate is affixed. When they are not known, the indicated characteristics are those allowed by the pattern approval certificate.

However, the minimum and the maximum temperatures of the liquids shall appear on the data plate only when they differ from – 10°C and + 50°C respectively.

The minimum measured quantity of the measuring system shall in all cases be clearly visible on the dial of any indicating device visible to the user during the measurement.

If several meters operate in a single system using common components, the marking required for each part of the system may be combined on a single plate.

When a measuring system can be transported without being dismantled, the markings required for each component may also be combined on a single plate.

(ii) Any information, markings or diagrams specified by this Recommendation or possibly by the pattern approval certificate, shall be clearly visible on the dial of the indicating device or within proximity to it.

The markings on the dial of the indicating device of a meter forming a part of a measuring system shall not contravene those on the data plate of the measuring system.

(iii) When volume at base conditions is indicated, these base conditions shall be clearly mentioned in the vicinity of the result of measurement, in the form :

T_b = ... °C (or K)

P_b = ... MPa (or kPa or Pa or bar).

(20) Sealing devices and stamping plate

(i) General

Sealing is preferably carried out by means of lead seals. However, other types of sealing are permitted on fragile instruments or when these seals provide sufficient integrity, electronic seals for instance.

The seals shall, in all cases, be easily accessible.

Sealing should be provided on all parts of the measuring system which cannot be materially protected in any other way against operations liable to affect the measurement accuracy.

It must be prohibited to change parameters which participate in the determination of the results of measurement (parameters for correction and conversion in particular) by means of sealing devices.

Except for direct selling to the public, it may be acceptable that the nature of the measured liquid or its viscosity be manually entered into the calculator at the beginning of the measurement operation [see paragraph 3(1)(v)], even when this datum participates in the correction. This datum and a note explaining that this quantity has been entered manually shall then be printed at the same time as the measurement results.

A plate, referred to as the stamping plate, aimed at receiving the control marks, shall be sealed or permanently attached on a support of the measuring system. It may be combined with the data plate of the measuring system referred to in paragraph 2(19).

In the case of a measuring system used for potable liquids, sealing shall be applied

such that the equipment may be dismantled for cleaning purposes.

(ii) Electronic sealing devices

(a) When access to parameters that participate in the determination of results of measurement is not protected by mechanical sealing devices, the protection shall fulfil the following provisions (except in cases related to the 5th paragraph of paragraph 2(20)(i):—

(aa) access shall only be allowed to authorized people, e.g. by means of a code (key-word) or of a special device (hard key, etc.); the code must be changeable; access by means of only a code is not allowed in the case of direct selling to the public;

(bb) it shall be possible for at least the last intervention to be memorized; the record shall include the date and a characteristic element identifying the authorized person making the intervention [see (a) above]; the traceability of the last intervention shall be assured for at least two years, if it is not over-written on the occasion of a further intervention; if it is possible to memorize more than one intervention, and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

(b) For measuring systems with parts which may be disconnected one from another by the user and which are interchangeable, the following provisions shall be fulfilled:—

(aa) it shall not be possible to access parameters that participate in the determination of results of measurements through disconnected points unless the provisions in 2(20)(ii)(a) are fulfilled;

(bb) interposing any device which may influence the accuracy shall be prevented by means of electronic and data processing securities or, if not possible, by mechanical means.

(c) For measuring systems with parts which may be disconnected one from another by the user and which are not interchangeable, the provisions in 2.20.2.2 apply. Moreover, these measuring systems shall be provided with devices which do not allow them to operate if the various parts are not associated according to the manufacturer's configuration.

Note: Disconnections which are not allowed to the user may be prevented, for example by means of a device that prevents any measurement after disconnecting and reconnecting.

3. Requirements for meters and ancillary devices of a measuring system

(1) Meter

The meter(s) of a measuring system shall meet the following requirements, whether or not it (they) is (are) subject to a separate pattern approval:—

(i) Field of operation

(a) The field of operation of a meter is determined at least by the following characteristics:—

(aa) minimum measured quantity;

(bb) measuring range limited by the minimum flowrate, Q_{min}, and the maximum flowrate, Q_{max},

(cc) maximum pressure of the liquid, P_{max},

(dd) nature of the liquid(s) to be measured and limits of kinematic or dynamic viscosity when the indication of the nature of the liquid alone is not sufficient for characterizing its viscosity,

(ee) maximum temperature of the liquid, T_{max},

(ff) minimum temperature of the liquid, T_{min}.

(b) The value of the minimum measured quantity shall be in the form 1×10^n, 2×10^n or 5×10^n authorised units of volume, n being a positive or negative whole number, or zero.

(c) In general, the ratio between the maximum and the minimum flowrate of the meter shall be:—

(i) at least equal to ten for meters

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for liquids having a viscosity less than 20 MPa.s at measurement temperature, other than liquefied gases,

(ii) at least equal to five for meters for liquids having a viscosity equal to or greater than 20 MPa.s and for meters for liquefied gases.

However, when the requirements applicable to a particular measuring system specify a lower ratio for that system or its meter, the ratio for the meter may be less than specified above, without being lower than two in application of 2.3(iii).

(ii) Metrological requirements

(a) The maximum permissible errors for a meter, within its field of operation, are equal to those specified in line B of Table 2.

(b) For any quantity equal to or greater than five times the minimum measured quantity, the repeatability error of the meter shall not be higher than two-fifths of the value specified in line A of Table 2.

(c) For a given liquid within their fields of operation, meter shall present a magnitude of the difference between the initial intrinsic error and the error after the endurance test equal to or less than the value specified in line B in Table 2.

(iii) Connections between the flow sensor and the indicating device

In the text, the expression "flow sensor" also means "volume sensor".

The connections between the flow sensor and the indicating device shall be reliable and, for electronic devices, durable, in accordance with paragraphs 4(1)(iii) and 4(3)(ii).

This provision also applies to connections between primary and secondary devices for electromagnetic meters.

(iv) Adjustment device

Meters may be provided with an adjustment device which permits modification of the ratio between the indicated volume and the actual volume of liquid passing through the meter, by a simple command.

When this adjustment device modifies this ratio in a discontinuous manner, the consecutive values of the ratio shall not differ by more than 0.0005 for meters intended to equip measuring systems of class 0.3, and 0.001 for other meters.

Adjustment by means of a bypass of the meter is prohibited.

(v) Correction device

Meters may be fitted with correction devices; such devices are always considered as an integral part of the meter. The whole of the requirements which apply to the meter, in particular the maximum permissible errors specified in paragraph 3(1)(ii)(a), are therefore applicable to the corrected volume (at metering conditions).

In normal operation, non-corrected volume shall not be displayed.

The aim of a correction device is to reduce the errors as close to zero as possible.

All the parameters which are not measured and which are necessary for correcting shall be contained in the calculator at the beginning of the measurement operation.

The correction device shall not allow the correction of a pre-estimated draft in relation to time or volume flow, for example.

Associated measuring instruments shall be fitted with checking devices, as specified in paragraph 4(3)(vi).

(vi) Measuring systems equipped with volumetric meters

The periodic variation of a volumetric meter shall be less than half the minimum specified volume deviation.

When a volumetric meter is approved separately, the pattern approval certificate shall indicate the value of its cyclic volume.

(vii) Measuring systems equipped with turbine meters

(a) The pressure downstream of the meter shall satisfy the manufacturer's specification. The minimum pressure shall be indicated on the data plate of the meter.

(b) Measuring systems equipped with turbine meters shall be fitted with flow straightening devices for preventing, as far as possible, the liquid from any possible rotation and for regulating the flow at the inlet of the meter. These are straight pipes, or flow straighteners, or a combination of straight pipes and a flow straightener.

The flow straightening device shall be placed immediately upstream of the meter and its internal diameter shall be equal to the diameter of the inlet of the meter.

The length of the necessary straight pipes and the characteristics of the flow straighteners are specified by the pattern approval of turbine meters.

(c) Each turbine meter shall be followed by a straight pipe having an internal diameter equal to the outlet diameter of the meter and a length of at least five times this diameter.

(viii) Measuring systems equipped with electromagnetic meters

(a) Measuring systems equipped with electromagnetic meters shall be fitted with a straight pipe upstream of the meter and with a straight pipe downstream of the meter.

The upstream pipe shall have an internal diameter equal to the inlet diameter of the meter and a length of at least ten times this diameter.

The downstream pipe shall have an internal diameter equal to the outlet diameter of the meter and a length of at least five times this diameter.

(b) The time necessary for determining the minimum measured quantity at maximum flow rate, must be at least twenty times the duration of one complete cycle for meters using a.c. or pulsed d.c. field excitation.

(c) The maximum permissible cable length between primary and secondary devices, shall be not more than 100 metres or not more than the value L expressed in metres according to the following formula, whichever is smaller:

$$L = (k \times c)/(f \times C)$$

Where:

$k = 2 \times 10^{-5}$m

c is the conductivity of the liquid, in S/m

f is the field frequency during the measuring cycle, in Hz

C is the effective cable capacitance per metre, in F/m

(2) Indicating device

(i) General provisions

(a) Reading of the indications shall be precise, easy and non-ambiguous whatever position the indicating device comes to rest; if the device comprises several elements, it shall be arranged in such a way that the reading of the measured volume can be made by simple juxtaposition of the indications of the different elements. The decimal sign shall appear distinctly.

(b) The scale interval of indication shall be in the form 1×10^n, 2×10^n or 5×10^n authorized units of volume, where n is a positive or negative whole number, or zero.

(c) Non-significant scale intervals should be avoided. This does not apply to price indications.

(d) The minimum specified volume deviation shall be equal to or greater than the following value:—

(i) for continuous indicating devices, the volume corresponding to 2mm