



Australian Government

**National Measurement
Institute**



NMI R 117

Measuring Systems for Liquids Other than Water

(OIML R 117:1995(E), MOD)

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PREFACE

NMI R 117 specifies the mandatory metrological and technical requirements for the pattern approval of measuring systems for liquids other than water. It is a modified version of OIML R 117:1992, *Measuring Systems for Liquids other than Water* published by the International Organisation of Legal Metrology (OIML).

NMI R 117 differs in some details from OIML R 117 and the differences are marked. Replaced text is marked and struck through in blue and deleted text is struck through in red. These differences give requirements specific to Australia and therefore were not included in the international recommendation.

Several references are made to other OIML and international publications. Where there is an Australian equivalent, reference is made to both documents, otherwise only the international document is referenced.

INTERPRETATION

NMI has decided to allow a reduced environmental temperature range requirement for volume measuring instruments that is more practical for Australian outdoor applications.

Although approval to OIML requirements as defined in NMI R 117 is -25°C to 55°C (i.e. class C), we are now allowing (on request) the approval of volume measuring instruments exclusively for use in Australia over a temperature range of -10°C to 55°C . This environment classification is class N (where N stands for national).

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE



INTERNATIONAL RECOMMENDATION

Measuring systems for liquids other than water

Ensembles de mesurage de liquides autres que l'eau

OIML R 117

Edition 1995 (E)

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FOREWORD

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- 1) **International Recommendations (OIML R)**, which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;
- 2) **International Documents (OIML D)**, which are informative in nature and intended to improve the work of the metrological services.

OIML Draft Recommendations and Documents are developed by technical committees or subcommittees which are formed by the Member States. Certain international and regional institutions also participate on a consultation basis.

Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

OIML publications may be obtained from the Organization's headquarters:

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This publication - reference OIML R 117, edition 1995 (E) - was developed by the OIML subcommittee TC 8/SC 3 *Dynamic volume measurement (liquids other than water)*. It was approved for final publication by the International Committee of Legal Metrology in 1994 and will be submitted to the International Conference of Legal Metrology in 1996 for formal sanction. It supersedes the former Recommendations Rs 5, 27, 57, 67, and 77.

TERMINOLOGY

The terminology used in this Recommendation conforms to the *International Vocabulary of Basic and General Terms in Metrology* (VIM - 1993 edition) and the *Vocabulary of Legal Metrology* (VML - 1978 edition). In addition, for the purposes of this Recommendation, the following definitions apply.

- Notes: 1) This terminology must be considered as a part of this Recommendation.
2) The following terminology is classified from a functional point of view. Annex C gives classifications by alphabetic order and by theme.

T.1 Measuring system and its constituents

T.1.1 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.

T.1.2 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 Recommendation, the measurement transducer includes the flow or volume sensor.

T.1.3 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.

T.1.4 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.

T.1.5 Ancillary device

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

Main ancillary devices are:

- zero setting device,
- repeating indicating device,
- printing device,
- memory device,
- price indicating device,
- totalizing indicating device,
- conversion device,
- pre-setting device,
- self-service device.

Note: An ancillary device may or may not be subject to legal metrology control according to its function in the measuring system or to national regulations.

T.1.6 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:

- gas elimination device,
- gas indicator,
- sight glass,
- filter, pump,
- device used for the transfer point,
- anti-swirl device,
- branches or bypasses,
- valves, hoses.

T.1.7 Measuring system

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

T.1.8 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.

T.1.9 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.

T.1.10 Associated measuring instruments

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

T.1.11 Correction device

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

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

T.1.12 Conversion device

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.

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

T.1.13 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).

T.1.14 Base conditions

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

Notes:

- 1) 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.
- 2) The values chosen as base conditions should preferably be 15 °C ~~or 20 °C~~, and 101 325 Pa.

T.1.15 Transfer point

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

T.1.16 Gas separator

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

Note: In general, devices defined from T.1.16 to T.1.19 are called gas elimination devices.

T.1.17 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.

T.1.18 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.

T.1.19 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.

T.1.20 Gas indicator

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

T.1.21 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.

T.2 Specific types of measuring systems

T.2.1 Fuel dispenser

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

- T.2.2 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.
- T.2.3 Aircraft refuelling tanker measuring system
 A tanker mounted measuring system intended for refuelling aircraft, supplied from a tank mounted on the vehicle.
- T.2.4 Aircraft hydrant measuring system
 A mobile measuring system intended for refuelling aircraft, supplied from hydrant pits.
- T.2.5 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.
- T.2.6 Self-service arrangement
 An arrangement that allows the customer to use a measuring system for the purpose of obtaining liquid for his own purchase.
- T.2.7 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.
- T.2.8 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:
 1) In attended service mode, the settlement of the transaction takes place before the customer leaves the site of the delivery.
 2) 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.
 3) 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).
 4) In attended service mode the measurement operation ends at the moment settlement of the transaction takes place.
- T.2.9 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 and/or memorizing) of information concerning the measurement operation.

T.2.10 Pre-payment

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

T.2.11 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.

T.2.12 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.

T.2.13 Authorization of a measuring system

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

T.2.14 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:

- 1) The consumer can be any person. Generally the consumer is the buyer but he can also be the seller.
- 2) 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.

T.3 Metrological characteristics

T.3.1 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.

T.3.2 Absolute error of measurement

The result of a measurement minus the (conventional) true value of the measurand. [VIM 3.10]

T.3.3 Relative error

The absolute error of measurement divided by the (conventional) true value of the measurand. [VIM 3.12]

T.3.4 Maximum permissible errors

The extreme values permitted by the present Recommendation for an error.

Notes:

- 1) In this text, maximum permissible errors are stated, according to the case, as relative errors (general case) or absolute errors.
- 2) To simplify writing, some specifications in the present text involve 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. In this case, it is obvious that it is the absolute maximum permissible error, associated with the relative maximum permissible error, which applies.

T.3.5 Minimum measured quantity of a measuring system

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

Note: In measuring systems intended to deliver, this smallest volume is referred to as the minimum delivery; in those intended for receiving operations, it is referred to as the minimum receipt.

T.3.6 Minimum specified volume deviation

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

T.3.7 Minimum specified price deviation

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

T.3.8 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.

T.3.9 Intrinsic error

The error of a measuring system used under reference conditions.

T.3.10 Initial intrinsic error

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

T.3.11 Fault (*)

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

T.3.12 Significant fault (*)

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

- one fifth of the magnitude of the maximum permissible error for the measured volume,
- the minimum specified volume deviation.

(*) Definitions of terms marked with (*) are relevant to electronic measuring systems only.

The following are not considered to be significant faults:

- faults arising from simultaneous and mutually independent causes in the measuring instrument itself or in its checking facilities,
- transitory faults being momentary variations in the indication, which cannot be interpreted, memorized or transmitted as a measurement result,
- faults implying the impossibility of performing any measurement.

T.3.13 Durability (*)

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

T.3.14 Interruptible/non interruptible measuring system

A measuring system is considered as interruptible/non interruptible when the liquid flow can/cannot be stopped easily and rapidly.

T.3.15 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.

T.3.16 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.

T.3.17 First element of an indicating device

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

T.4 Test conditions

T.4.1 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. [VIM 2.7]

T.4.2 Influence factor (*)

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

(*) See note to T.3.11.

- T.4.3 Disturbance (*)
 An influence quantity having a value within the limits specified hereafter in this International Recommendation, 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.
- T.4.4 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.
- T.4.5 Reference conditions
 A set of specified values of influence factors fixed to ensure valid intercomparison of results of measurements. [Adapted from VIM 5.7]
- T.4.6 Performance test
 A test intended to verify whether the measuring system under test (EUT) is capable of accomplishing its intended functions.
- T.4.7 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.
- T.4.8 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.
- T.5 Electronic or electrical equipment
- T.5.1 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 T.1.1 through T.1.5.
- T.5.2 Electronic sub-assembly
 A part of an electronic device, employing electronic components and having a recognizable function of its own.
- T.5.3 Electronic component
 The smallest physical entity which uses electron or hole conduction in semiconductors, gases, or in a vacuum.

(*) See note to T.3.11.

T.5.4 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.

T.5.5 Automatic checking facility

A checking facility operating without the intervention of an operator.

T.5.6 Permanent automatic checking facility (type P)

An automatic checking facility operating during the entire measurement operation.

T.5.7 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.

T.5.8 Nonautomatic checking facility (type N)

A checking facility which requires the intervention of an operator.

T.5.9 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.

MEASURING SYSTEMS FOR LIQUIDS OTHER THAN WATER

1 Field of application

1.1 Scope

This Recommendation specifies 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 Recommendation applies to all measuring systems fitted with a meter as defined in T.1.1 (continuous measurement), whatever be the measuring principle of the meters or their application, except:

- drum meters for alcohol (OIML R 86),
- measuring systems for cryogenic liquids (OIML R 81),
- direct mass measuring systems (~~OIML R 105~~).

However, the provisions in clause 4 may apply to electronic measuring systems for ~~alcohol and for~~ cryogenic liquids. This Recommendation 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 (certain aspects of vortex meters being covered by OIML D 25). It will then be appropriate to decide whether such meters should be included in the scope of this Recommendation.~~

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

National or international regulations are expected to clearly specify which measuring systems for liquids other than water are subject to legal metrology controls.

1.2 Liquids to be measured

Measuring systems that are covered by this Recommendation may be used for the following liquids:

- liquid petroleum and related products: crude oil, liquid hydrocarbons, liquefied petroleum gas (LPG), liquid fuel, lubricants, industrial oils, etc. (see e.g. ISO 1998-1, 1998-2, 6743-0, 8216-0);
- liquid food: dairy products (milk, cream, etc.), beer and brewer's wort, ~~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.);
- alcohol: pure ethanol (ethyl alcohol) and mixtures of only ethanol and water (except drum meters for alcohol);

- chemical products in liquid state: HCl, H₂SO₄, ammonia water etc.;
- other liquids: all other liquids except cold potable water and hot water (see OIML R 49 and R 72); examples: distilled water and deionized water, liquids used for calibration of tanks.

Note: For waste water it is up to the national authorities to decide if the use of measuring systems conforming to this Recommendation is mandatory or not, and which may be their accuracy class.

2 General requirements

2.1 Constituents of a measuring system

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

- a meter,
- a transfer point,
- a hydraulic circuit with particular characteristics which must be taken into account.

For correct operation, it is often necessary to add to this set:

- a gas elimination device,
- a filter device,
- a pumping device,
- correction devices related to temperature, viscosity, etc.

The measuring system may be provided with other ancillary and additional devices (see 2.2).

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.

2.2 Ancillary devices

2.2.1 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 (for example).

As a rule these ancillary devices are optional. However, this Recommendation makes some of them mandatory, or prohibits some of them, for particular types of measuring systems. In addition, ~~national or international regulations may make some of these devices mandatory in relation to the utilization of the measuring systems (*)~~.

(*) It is advisable, in particular, that national or international regulations include provisions prescribing that primary indications shall remain accessible to the parties interested in a transaction up to the settlement of this transaction (see notes 2 and 3 to T.2.8). It is not required that the parties interested in a transaction shall be provided permanently with the results of measurement, but only that they may have access to these results (for example, in case of a dispute). In addition, in the case of self-service (filling station, truck filling station) the owner of the measuring system is considered to have access to the indications of the measuring system even when he does not use this possibility in practice.

2.2.2 When these ancillary devices are mandatory in application of this Recommendation or of a national or international regulation, they are considered as integral parts of the measuring system, they are subject to control, and they shall meet the requirements of this Recommendation.

2.2.3 When ancillary devices are not subject to control, one shall verify that these devices do not affect the correct operation of the measuring system. In particular, the system shall continue to operate correctly and its metrological functions shall not be affected when the peripheral equipment is connected.

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 shall be present on each print-out likely to be made available to the customer.

2.3 Field of operation

2.3.1 The field of operation of a measuring system is determined by the following characteristics:

- minimum measured quantity,
- measuring range limited by the minimum flowrate, Q_{\min} , and the maximum flowrate, Q_{\max} ,
- maximum pressure of the liquid, P_{\max} ,
- minimum pressure of the liquid, P_{\min} ,
- 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,
- maximum temperature of the liquid, T_{\max} ,
- minimum temperature of the liquid, T_{\min} ,
- environmental class (see A.2).

2.3.2 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.

2.3.3 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 for 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.

2.3.4 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 (meters, 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 meters are taken into consideration, especially the sum of the limiting flowrates, to verify if the measuring system meets the provision above.

2.4 Accuracy classes

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

Table 1

Class	Field of application
0.3	Measuring systems on pipeline (see 5.6)
0.5	All measuring systems if not differently stated elsewhere in this table, in particular: <ul style="list-style-type: none"> • fuel dispensers for motor vehicles (other than LPG dispensers) (see 5.1 and 5.9) • measuring systems on road tankers for liquids of low viscosity (see 5.2) • measuring systems for the unloading of ships' tanks and rail and road tankers (see 5.3) • measuring systems for milk (see 5.5) • measuring systems for loading ships (see 5.6) • measuring systems for refuelling aircraft (see 5.8)
1.0	Measuring systems (other than LPG dispensers) for liquefied gases under pressure measured at a temperature equal to or above $-10\text{ }^{\circ}\text{C}$ (see 5.4) LPG dispensers for motor vehicles (see 5.7) Measuring systems normally in class 0.3 or 0.5 but used for liquids: <ul style="list-style-type: none"> • whose temperature is less than $-10\text{ }^{\circ}\text{C}$ or greater than $50\text{ }^{\circ}\text{C}$, or • whose dynamic viscosity is higher than $1000\text{ mPa}\cdot\text{s}$, or • whose maximum volumetric flowrate is not higher than 20 L/h
1.5	Measuring systems for liquefied carbon dioxide (see 5.4.10), Measuring systems (other than LPG dispensers) for liquefied gases under pressure measured at a temperature below $-10\text{ }^{\circ}\text{C}$ (see 5.4)
2.5	Measuring systems for liquids at a temperature below $-153\text{ }^{\circ}\text{C}$

2.5 Maximum permissible errors

2.5.1 For volumes not smaller than two litres, and without prejudice to 2.5.3, 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	2.5
A (*)	0.3 %	0.5 %	1.0 %	1.5 %	2.5 %
B (*)	0.2 %	0.3 %	0.6 %	1.0 %	1.5 %

(*) See 2.6.

2.5.2 For volumes smaller than two litres, and without prejudice to 2.5.3, 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

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

- absolute value of the maximum permissible error given in Table 2 or Table 3,
- 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.

2.6 Conditions for applying maximum permissible errors

Provisions in this subclause apply to volume indications at metering conditions (see 2.7 for converted indications).

2.6.1 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:

- pattern approval,
- initial verification in one stage or the second stage of a two-stage initial verification,
- subsequent verifications.

2.6.2 Maximum permissible errors in line B of Table 2 apply to:

- pattern approval of a meter, for all liquids, all temperatures and all pressures of the liquids, and all flowrates for which the system is intended to be approved,
- initial verification (first stage of the verification) of a meter intended to be fitted in a measuring system subject to a two-stage initial verification.

Notes:

1) 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.

2) If the meter is provided with an adjustment or correction device, it is sufficient to verify that the error curve(s) is (are) within a range of two times the value specified in line B of Table 2.

3) See example in 6.1.5.2.4.

2.6.3 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 2.6.1 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 2.6.2 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.

2.7 Provisions for converted indications

2.7.1 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:

- one-half scale interval of the indicating device for converted indications,
- half of the value corresponding to the minimum specified volume deviation.

2.7.2 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 2.7.3).

Table 4

Maximum permissible errors on measuring:	Accuracy classes of the measuring system				
	0.3	0.5	1.0	1.5	2.5
Temperature	± 0.3 °C	± 0.5 °C			± 1 °C
Pressure	less than 1 MPa : ± 50 kPa between 1 and 4 MPa : ± 5 % more than 4 MPa : ± 200 kPa				
Density	± 1 kg/m ³		± 2 kg/m ³		± 5 kg/m ³

2.7.3 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 2.7.2. However the magnitude of the maximum permissible error shall not be less than one-half scale interval of the indicating device for converted indications.

2.7.4 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. by 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.

2.7.5 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 2.7.4 can be applied by analogy.

2.8 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.

2.9 Indications

2.9.1 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.

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

Without prejudice to the provisions in 2.9.3, 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.

2.9.3 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.

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

2.9.5 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 5.10.1.3).

2.9.6 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:

- it is impossible to use any two of these measuring systems simultaneously,
- 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.

2.10 Elimination of air or gases

2.10.1 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.

2.10.2 Pumped flow

A gas separator shall be provided when, subject to the provisions in 2.10.4, the pressure at the pump inlet may, even momentarily, fall below either the atmospheric pressure or the saturated vapor 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 vapor 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 pipework 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 vapor 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:

- 1) gaseous formations likely to occur owing to thermal contraction during shutdown periods; if gaseous formation is possible, a gas extractor is required.
- 2) 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.

2.10.3 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 vapor 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 vapor 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 vapor pressure of the liquid.

2.10.4 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.

2.10.5 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.

2.10.6 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.

2.10.7 General provisions for gas elimination devices

2.10.7.1 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.

2.10.7.2 The operational limits of a gas elimination device are as follows:

- a) the maximum flowrate(s) for one or more specified liquids,
- b) 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,
- c) the minimum measured quantity for which it is designed.

2.10.8 Special provisions applicable to gas separators

2.10.8.1 Within the error limits specified in 2.10.1, a gas separator fitted in a measuring system that does not incorporate a gas indicator as specified in 2.11, shall ensure the elimination of air or gases mixed with the liquid to be measured under the following test conditions:

- a) without air or gases the measuring system operates at the maximum flowrate and at the minimum pressure specified for the gas separator,
- b) 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 m³/h; it is limited to 30 % if the gas separator is designed for a maximum flowrate higher than 20 m³/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.

2.10.8.2 Within the error limits specified in 2.10.1, 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:

- a) without air or gases the measuring system operates at the maximum flowrate and at the minimum pressure specified for the measuring system,
- b) 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.

2.10.9 Special provisions applicable to gas extractors

A gas extractor or special gas extractor shall, at the maximum flowrate of the measuring system, ensure the 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 2.10.1.

Notes:

- 1) A special gas extractor is used mainly in measuring systems mounted on road tankers.
- 2) Installing a special gas extractor is subject to feeding conditions. Therefore, no performance is required for proportions greater than 5 %.

2.11 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 pipework. 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.

2.12 Transfer point

2.12.1 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.

2.12.2 Measuring systems may be of two types: "empty hose" systems and "full hose" systems: the term "hose" includes rigid pipework.

2.12.2.1 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.

2.12.2.2 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.

2.12.2.3 In the case of receiving equipment, the same provisions apply by analogy to the reception pipework upstream of the meter.

2.13 Complete filling of the measuring system

2.13.1 The meter and the pipework 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.

2.13.2 The additional effect of the pipework 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 $1 \cdot 10^{-3}$ per degree Celsius.

2.13.3 Subject to the provisions in 2.10.3, 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 vapor pressure of the liquid.

2.13.4 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.

2.13.5 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.

2.13.6 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.

2.13.7 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.

2.14 Draining

2.14.1 In empty hose measuring systems, draining of the delivery hose referred to in 2.12.2.1 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 m³, 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.

2.14.2 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.

2.15 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.

2.16 Branches and bypasses

2.16.1 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 alternately 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.

2.16.2 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.

2.16.3 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.

2.17 Control and closing mechanisms

2.17.1 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.

2.17.2 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.

2.18 Various provisions

2.18.1 If provided, filters shall not disturb the measuring operation.

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

2.19 Markings

2.19.1 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 2.3.1, 3.1.1.1, 2.10.7.2, or 3.1.7.1,
- 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.

2.19.2 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.

2.19.3 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:

$$T_b = \dots \text{ }^\circ\text{C (or K)}$$

$$P_b = \dots \text{ MPa (or kPa or Pa or bar)}$$

2.20 Sealing devices and stamping plate

2.20.1 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 3.1.5, 4th paragraph) 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 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.

2.20.2 Electronic sealing devices

2.20.2.1 When access to parameters that participate in the determination of results of measurement is not protected by mechanical sealing devices, the protection shall fulfill the following provisions (except in cases related to the 5th paragraph of 2.20.1):

- a) access shall only be allowed to authorized people, e.g. by means of a code (keyword) 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;
- b) 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.

2.20.2.2 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:

- a) it shall not be possible to access parameters that participate in the determination of results of measurements through disconnected points unless the provisions in 2.20.2.1 are fulfilled;
- b) 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.

2.20.2.3 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

3.1 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:

3.1.1 Field of operation

3.1.1.1 The field of operation of a meter is determined at least by the following characteristics:

- minimum measured quantity,
- measuring range limited by the minimum flowrate, Q_{\min} , and the maximum flowrate, Q_{\max} ,
- maximum pressure of the liquid, P_{\max} ,
- 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,
- maximum temperature of the liquid, T_{\max} ,
- minimum temperature of the liquid, T_{\min} .

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

3.1.1.3 In general, the ratio between the maximum and the minimum flowrate of the meter shall be:

- at least equal to ten for meters for liquids having a viscosity less than 20 mPa.s at measurement temperature, other than liquefied gases,
- 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 2.3.3, 3rd paragraph.

3.1.2 Metrological requirements

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

3.1.2.2 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.

3.1.2.3 For a given liquid within their fields of operation, meters 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.

3.1.3 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 4.1.3 and 4.3.2.

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

3.1.4 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.

3.1.5 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 3.1.2.1, 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.

Note: National regulations should state that the use of this device for adjusting the errors of a meter to values other than as close as practical to zero is forbidden, even when these values are within the maximum permissible errors.

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 pattern approval certificate may prescribe the possibility of checking parameters that are necessary for correctness at the time of verification of the correction device.

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

The associated measuring instruments, if any, shall comply with the applicable International Standards or Recommendations. Their accuracy shall be good enough to permit that the requirements on the meter be met, as specified in 3.1.2.1.

Associated measuring instruments shall be fitted with checking devices, as specified in 4.3.6.

3.1.6 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.

3.1.7 Measuring systems equipped with turbine meters

3.1.7.1 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.

3.1.7.2 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. In addition, application of the provisions in ISO 2715 is recommended for this specific point.

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

3.1.7.3 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.

Note: Requirements in 3.1.7.2 and 3.1.7.3 may be not fulfilled if the manufacturer's solutions ensure equivalent results.

3.1.8 Measuring systems equipped with electromagnetic meters

3.1.8.1 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.

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

3.1.8.3 The maximum permissible cable length between primary and secondary devices, as defined in ISO/TR 6817-1980, 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:

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

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

Note: Requirements in 3.1.8 may be not fulfilled if the manufacturer's solutions ensure equivalent results.

3.2 Indicating device

3.2.1 General provisions

3.2.1.1 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.

3.2.1.2 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.

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

3.2.1.4 The minimum specified volume deviation shall be equal to or greater than the following value:

- for continuous indicating devices, the volume corresponding to 2 mm on the scale or to one-fifth of the scale interval (of the first element for mechanical indicating devices), whichever is greater;
- for discontinuous indicating device, the volume corresponding to two scale intervals.

3.2.2 Mechanical indicating device

3.2.2.1 When the graduation of an element is entirely visible, the value of one revolution of that element shall be in the form 10^n authorized units of volume; this rule however, does not apply to the element corresponding to the maximum range of the indicating device.

3.2.2.2 On an indicating device having several elements, the value of each revolution of an element whose graduation is entirely visible must correspond to the scale interval of the following element.

3.2.2.3 An element of the indicating device may have continuous or discontinuous movement, but when elements other than the first have only part of their scales visible through the windows, these elements shall have discontinuous movement.

3.2.2.4 The advance by one figure of any element having discontinuous movement shall occur and be completed when the preceding element passes from 9 to 0.

3.2.2.5 When the first element has only a part of its scale visible through a window and has a continuous movement, the dimension of that window shall be at least equal to 1.5 times the distance between two consecutive graduated scale marks.

3.2.2.6 All scale marks shall have the same width, constant along the line and not exceeding one quarter of the scale spacing. The apparent scale spacing shall be equal to or greater than 2 mm. The apparent height of the figures shall be equal to or greater than 4 mm, unless otherwise specified in the requirements for particular measuring systems.

3.2.3 Electronic indicating device

The continuous display of volume during the period of measurement is only mandatory in the case of direct selling to the public. However, if interrupting the display of volume interrupts the action of some checking facilities that are mandatory or necessary to ensure correct measurement, the volume passing through the meter during each interruption shall be smaller than or equal to the minimum measured quantity.

3.2.4 Zero setting device for volume indicating device

3.2.4.1 A volume indicating device may be provided with a device for setting the indication to zero either by manual operation or by means of an automatic system.

3.2.4.2 The zero setting device shall not permit any alteration of the measurement result shown by the volume indicating device (other than by making the result disappear and displaying zeros).

3.2.4.3 Once the zeroing operation has begun it shall be impossible for the volume indicating device to show a result different from that of the measurement which has just been made, until the zeroing operation has been completed.

Indicating devices on fuel dispensers and electronic measuring systems shall not be capable of being reset to zero during measurement. On other measuring systems, either this provision shall be fulfilled or a clearly visible notice shall be provided on the indicating device stating that this operation is prohibited.

3.2.4.4 On continuous indicating devices, the residual indication after return to zero shall not be more than half the minimum specified volume deviation.

3.2.4.5 On discontinuous indicating devices, the indication after return to zero shall be zero without any ambiguity.

3.3 Price indicating device

3.3.1 A volume indicating device with aligned figures and zero setting may be complemented with a price indicating device, also with aligned figures and zero setting.

3.3.2 The selected unit price shall be displayed by an indicating device before the start of the measurement. The unit price shall be adjustable; changing the unit price may be carried out either directly on the measuring system or through peripheral equipment.

The indicated unit price at the start of a measurement operation shall be valid for the whole transaction. A new unit price shall only be effective at the moment a new measurement operation may start.

A time of at least 5 s shall elapse between indicating a new unit price and before the next measurement operation can start, if the unit price is set from peripheral equipment.

3.3.3 The provisions in 3.2 relating to volume indicating devices apply also, by analogy, to the price indicating devices.

3.3.4 The ~~monetary unit used~~, or its symbol, shall appear in the immediate vicinity of the indication.

3.3.5 The zero setting devices of the price indicating device and of the volume indicating device shall be designed in such a way that zeroing either indicating device automatically involves zeroing the other.

3.3.6 The minimum specified price deviation shall be greater than or equal to the following value:

- for continuous indicating devices, the price corresponding to 2 mm on the scale or to one-fifth of the scale interval (of the first element for mechanical indicating devices), whichever is greater,
- for discontinuous indicating devices, the price corresponding to two scale intervals.

However, the interval of one-fifth of the scale interval or of 2 mm in the case of the first hyphen or the scale interval in the case of the second hyphen needs not correspond to a value less than ~~that of the smallest coin in circulation in the country in which the equipment is used.~~

3.3.7 The difference between the indicated price and the price calculated from the unit price and the indicated volume shall not exceed the minimum specified price deviation. However this difference need not be less than ~~the smallest monetary value as defined in 3.3.6.~~

Moreover, this requirement does not apply when the unit price has been changed between two measurements.

3.3.8 On continuous indicating devices, the residual indication after zeroing shall not exceed half the minimum specified price deviation. However, this indication need not be less than ~~the smallest monetary value as defined in 3.3.6.~~

3.3.9 On discontinuous indicating devices, the indication after zeroing shall be zero without any ambiguity.

3.4 Printing device

3.4.1 The printed scale interval shall be in the form of 1×10^n , 2×10^n or 5×10^n authorized units of volume, n being a positive or negative whole number, or zero, and shall not be greater than the minimum specified volume deviation.

The printed scale interval shall not be smaller than the smallest scale interval of the indicating devices.

3.4.2 The volume printed shall be expressed in one of the units authorized for the indication of volume.

The figures, the unit used or its symbol and the decimal sign, if any, shall be printed on the ticket by the device.

3.4.3 The printing device may also print information identifying the measurement such as: sequence number, date, identification of the dispenser, type of liquid, etc.

If the printing device is connected to more than one measuring system, it must print the identification of the relevant system.

3.4.4 If a printing device allows repetition of the printing before a new delivery has started, copies shall be clearly marked as such, for example by printing "duplicate".

3.4.5 If the volume is determined by the difference between two printed values, even if one is expressed in zeros, it shall be impossible to withdraw the ticket from the printing device during measurement.

3.4.6 Where the printing device and volume indicating device each have a zeroing device, these devices shall be designed so that resetting one of them to zero also resets the other.

3.4.7 The printing device may print, in addition to the measured quantity, either the corresponding price or this price and the unit price.

In the case of “direct selling to the public” it may also print only the price to be paid (without the volume) when it is connected to a volume indicating device and to a price indicating device both of which are visible to the purchaser.

The figures, the ~~monetary unit~~ used or its symbol and the decimal sign, if any, shall be printed by the device.

3.4.8 The printed price scale interval shall be in the form 1×10^n , 2×10^n or 5×10^n monetary units, n being a positive or negative whole number, or zero; it shall not exceed the minimum specified price deviation. However, it need not be less than ~~the smallest monetary value specified in 3.3.6~~.

3.4.9 If the volume indicating device is not fitted with a price indicating device, the difference between the printed price and the price calculated on the basis of the indicated volume and the unit price shall comply with the requirements in 3.3.7.

3.4.10 Electronic printing devices are also subject to the requirements in 4.3.5.

3.5 Memory device

3.5.1 Measuring systems may be fitted with a memory device to store measurement results until their use or to keep a trace of commercial transactions, providing proof in case of a dispute. Devices used to read stored information are considered as included in the memory devices.

3.5.2 The medium on which data are stored must have sufficient permanency to ensure that the data are not corrupted under normal storage conditions. There shall be sufficient memory storage for any particular application.

3.5.3 When the storage is full, it is permitted to delete memorized data when both the following conditions are met:

- data are deleted in the same order as the recording order and the rules established for the particular application are respected,
- deletion is carried out after a special manual operation.

3.5.4 Memorization shall be such that it is impossible in normal use to modify stored values.

3.5.5 Memory devices shall be fitted with checking facilities according to 4.3.5. The aim of the checking facility is to ensure that stored data correspond to the data provided by the calculator and that restored data correspond to stored data.

3.6 Pre-setting device

3.6.1 The selected quantity is pre-set by operating a device provided with scales and scale marks or a numerical device which indicates that quantity. The preset quantity shall be indicated before the start of the measurement.

3.6.2 Where pre-setting is effected by means of several controls which are independent of each other, the scale interval corresponding to one control shall be equal to the pre-setting range of the control of the next lower order.

3.6.3 Pre-setting devices may be so arranged that the repetition of a selected quantity does not require a new setting of the controls.

3.6.4 Where it is possible to view simultaneously the figures of the display device of the pre-setting device and those of the volume indicating device, the former shall be clearly distinguishable from the latter.

3.6.5 Indication of the selected quantity may, during measurement, either remain unaltered or return progressively to zero. However, for an electronic pre-setting device it is acceptable to indicate the preset value on the indicating device for volume or price by means of a special operation with the restriction that this value shall be replaced by the zero indication for volume or price before the measurement operation can start.

3.6.6 In the case of a prepaid or pre-ordered delivery, the difference found under normal operating conditions, between the pre-set quantity and the quantity shown by the volume or price indicating device at the end of the measurement operation, shall not exceed the minimum specified volume or price deviation.

3.6.7 The pre-set quantities and the quantities shown by the volume indicating device shall be expressed in the same unit. This unit (or its symbol) shall be marked on the pre-setting mechanism.

3.6.8 The scale interval of the pre-setting device shall not be less than the scale interval of the indicating device.

3.6.9 Pre-setting devices may incorporate a device to permit the flow of liquid to be stopped quickly when necessary.

3.6.10 Measuring systems with a price indicating device may also be fitted with a price pre-setting device which stops the flow of the liquid when the quantity delivered corresponds to the pre-set price. The requirements in 3.6.1 to 3.6.9 apply by analogy.

3.7 Conversion device

3.7.1 Measuring systems may be fitted with a conversion device as defined in T.1.12. The provisions of this subclause 3.7 mainly apply to electronic conversion devices in which conversion calculations are made numerically by an electronic computer. Analogous provisions could apply by analogy to mechanical conversion devices.

3.7.2 The calculation of the conversion factor shall be made according to the applicable International Recommendations or Standards (in particular, OIML R 63), or other methods accepted for national use.

3.7.3 As a rule, the parameters which characterize the measured liquid and which intervene in the conversion formula shall be measured using associated measuring instruments. However, some of these parameters may be not measured, or associated measuring instruments may be not subject to control when their influence on the conversion factor is negligible (less than one-tenth of the maximum permissible error as specified in 2.5.1).

For example, in many cases it is possible to make a conversion to volume in base conditions by measuring temperature only, when pressure and density vary little.

3.7.4 Associated measuring instruments shall comply with applicable International Recommendations and Standards. In addition, maximum permissible errors for these instruments are those specified in 2.7.2.

3.7.5 Associated measuring instruments shall be installed near the meter so as to determine the relevant quantities as they exist in the meter in a sufficiently accurate way.

The changes in indication due to the location of the measuring points shall not exceed 0.2 times the maximum permissible error for the measuring system. Subject to fulfillment of this requirement, the same associated measuring instruments may be used for making conversions (and corrections) for several meters.

These instruments shall not affect the correct functioning of the meter(s).

Note: These requirements are checked by calculation.

3.7.6 All the parameters which are not measured and which are necessary for the conversion shall be present in the calculator at the beginning of the measurement operation. It must be possible to print or to indicate them from the calculator.

For a mechanical conversion device that cannot print or indicate these values, a seal must be broken to change any setting.

3.7.7 In addition to the volume at metering conditions and the volume in base conditions or the mass, which shall be displayed according to 2.9.2, the values of other measured quantities (density, pressure, temperature) shall be accessible for each test measurement.

Scale intervals for density, pressure and temperature shall be smaller than or equal to one quarter of the maximum permissible errors fixed in 2.7.2. for associated measuring instruments.

3.8 Calculator

All parameters necessary for the elaboration of indications that are subject to legal metrology control, such as unit price, calculation table, correction polynomial, etc. shall be present in the calculator at the beginning of the measurement operation.

The calculator may be provided with interfaces permitting the coupling of peripheral equipment. When these interfaces are used, the instrument shall continue to function correctly and its metrological functions shall not be capable of being affected.

4 Measuring systems equipped with electronic devices

4.1 General requirements

4.1.1 Electronic measuring systems shall be designed and manufactured such that their errors do not exceed the maximum permissible errors as defined in 2.5 under rated operating conditions.

4.1.1.1 Interruptible electronic measuring systems shall be designed and manufactured such that, when they are exposed to the disturbances specified in A.4:

- either a) significant faults do not occur,
- or b) significant faults are detected and acted upon by means of checking facilities.

This provision may apply separately to:

- each individual cause of significant fault and/or
- each part of the measuring system.

4.1.1.2 Non-interruptible measuring systems shall be designed and manufactured in such a way that no significant faults occur when they are exposed to the disturbances specified in A.4.

4.1.2 It is the responsibility of the manufacturer to decide whether a given pattern of measuring system is interruptible or not, taking into account the applicable rules of security. However, measuring systems for direct selling to the public shall be interruptible.

When, at the time of pattern approval, it is not possible to specify the future utilization of the instrument, the requirements in 4.1.1.2 apply.

4.1.3 The requirements in 4.1.1 shall be met durably. For this purpose electronic measuring systems shall be provided with the checking facilities specified in 4.3.

4.1.4 A pattern of a measuring system is presumed to comply with the requirements in 4.1.1 and 4.1.3 if it passes the inspection and tests specified in 6.1.11.1 and 6.1.11.2.

4.1.5 Measuring systems shall permit the retrieval of the information relating to the measured volume contained within the instrument when a significant fault occurred and was detected by checking facilities.

4.2 Power supply device

4.2.1 When the flow is not interrupted during the failure of the principal power supply device, the measuring system shall be provided with an emergency power supply device to safeguard all measuring functions during that failure.

4.2.2 When the flow is interrupted during the failure of the principal power supply device, the provisions in 4.2.1 shall be met, or data contained at the moment of the failure shall be saved and displayable on an indicating device subject to legal metrology control for sufficient time to permit the conclusion of the current transaction.

The absolute value of the maximum permissible error for the indicated volume in this case is increased by 5 % of the minimum measured quantity.

4.3 Checking facilities

4.3.1 Action of checking facilities

The detection by the checking facilities of significant faults shall result in the following actions, according to the type.

4.3.1.1 Checking facilities of type N: a visible or audible alarm for the attention of the operator.

4.3.1.2 Checking facilities of types I or P:

a) for non-interruptible measuring systems:

- automatic correction of the fault, or
- stopping only the faulty device when the measuring system without that device continues to comply with the regulations, or
- a visible or audible alarm for the operator; this alarm shall continue until the cause of the alarm is suppressed. In addition, when the measuring system transmits data to peripheral equipment, the transmission shall be accompanied by a message indicating the presence of a fault.

Note: The third hyphen is not applicable for the disturbances specified in A.4. In addition, the instrument may be provided with devices to estimate the amount of liquid having passed through the installation during the occurrence of the fault. The result of this estimate shall not be capable of being mistaken for a valid indication.

b) for interruptible measuring systems, in particular for fuel dispensers:

- automatic correction of the fault, or
- stopping only the faulty device, when the measuring system without that device continues to comply with the regulations, or
- stopping the flow.

4.3.2 Checking facilities for the measurement transducer

The objective of these checking facilities is to verify the presence of the transducer, its correct operation and the correctness of data transmission.

4.3.2.1 When the signals generated by the flow sensor are in the form of pulses, each pulse representing an elementary volume, at least security level B defined by ISO 6551 [Cabled transmission of electric and/or electronic pulsed data](#) is required.

These checking facilities shall be of type P and the checking shall occur at time intervals not exceeding the duration of the measurement of an amount of liquid equal to the minimum specified volume deviation.

It shall be possible during pattern approval and initial verification to check that these checking facilities function correctly:

- by disconnecting the transducer, or
- by interrupting one of the sensor's pulse generators, or
- by interrupting the electrical supply of the transducer.

4.3.2.2 For electromagnetic meters only, where the amplitude of the signals generated by the measurement transducer is proportional to the flowrate, the following procedure may be used:

A simulated signal with a shape similar to that of the measurement signal is fed into the input of the secondary device, representing a flowrate between the minimum and

maximum flowrate of the meter. The checking facility shall check the primary and the secondary device. The equivalent digital value is checked to verify that it is within predetermined limits given by the manufacturer and consistent with the maximum permissible errors.

This checking facility shall be of type P or I. In the latter case, the checking shall occur at least every five minutes.

Note: Following this procedure, additional checking facilities (more than two electrodes, double signal transmission etc.) are not required.

4.3.2.3 For other technologies checking facilities providing equivalent levels of security remain to be developed.

4.3.3 Checking facilities for the calculator

The objective of these checking facilities is to verify that the calculator system functions correctly and to ensure the validity of the calculations made.

There are no special means required for indicating that these checking facilities function correctly.

4.3.3.1 The checking of the functioning of the calculation system shall be of types P or I. In the latter case, the checking shall occur at least every five minutes, except in the case of fuel dispensers, for which it shall occur at each delivery. The objective of the checking is to verify that:

- a) the values of all permanently memorized instructions and data are correct, by such means as:
 - summing up all instruction and data codes and comparing the sum with a fixed value,
 - line and column parity bits (LRC and VRC),
 - cyclic redundancy check (CRC 16),
 - double independent storage of data,
 - storage of data in "safe coding", for example protected by checksum, line and column parity bits,
- b) all procedures of internal transfer and storage of data relevant to the measurement result are performed correctly, by such means as:
 - write-read routine,
 - conversion and reversion of codes,
 - use of "safe coding" (check sum, parity bit),
 - double storage.

4.3.3.2 The checking of the validity of calculations shall be of type P. This consists of checking the correct value of all data related to the measurement whenever these data are internally stored or transmitted to peripheral equipment through an interface; this check may be carried out by such means as parity bit, check sum or double storage. In addition, the calculation system shall be provided with a means of controlling the continuity of the calculation program.

4.3.4 Checking facility for the indicating device

The objective of this checking facility is to verify that the primary indications are displayed and that they correspond to the data provided by the calculator. In addition, it aims at verifying the presence of the indicating devices, when they are removable. These checking facilities shall either have the form as defined in 4.3.4.1 or the form as defined in 4.3.4.2.

4.3.4.1 The checking facility of the indicating device is of type P; however, it may be of type I if a primary indication is provided by another device of the measuring system, or if the indication may be easily determined from other primary indications (for example, in the case of a fuel dispenser it is possible to determine the price to pay from the volume and the unit price).

Means may include, for example:

- for indicating devices using incandescent filaments or LEDs, measuring the current in the filaments,
- for indicating devices using fluorescent tubes, measuring the grid voltage,
- for indicating devices using electromagnetic shutters, checking the impact of each shutter,
- for indicating devices using multiplexed liquid crystals, output checking of the control voltage of segment lines and of common electrodes, so as to detect any disconnection or short circuit between control circuits.

4.3.4.2 The checking facility for the indicating device shall include type I or type P checking of the electronic circuits used for the indicating device (except the driving circuits of the display itself); this checking shall meet the requirements in 4.3.1.2.

It shall also provide visual checking of the entire display which shall meet the following description:

a) for fuel dispensers:

- displaying all the elements (“eights” test)
- blanking all the elements (“blank” test)
- displaying “zeros”

Each step of the sequence shall last at least 0.75 second.

b) for all other measuring systems, the test sequence as described under (a) or any other automatic test cycle which indicates all possible states for each element of the display.

This visual checking facility shall be of type I for fuel dispensers and of type N for other measuring systems, but it is not mandatory for a malfunction to result in the actions described in 4.3.1.

4.3.4.3 It shall be possible during verification to determine that the checking facility of the indicating device is working, either:

- by disconnecting all or part of the indicating device, or
- by an action which simulates a failure in the display, such as using a test button.

4.3.5 Checking facilities for ancillary devices

An ancillary device (repeating device, printing device, self-service device, memory device, etc.) with primary indications shall include a checking facility of type I or P. The object of this checking facility is to verify the presence of the ancillary device, when it is a necessary device, and to verify the correct transmission of data from the calculator to the ancillary device.

In particular, the checking of a printing device aims at ensuring that the printing controls correspond to the data transmitted by the calculator. At least the following shall be checked:

- presence of paper,

- the electronic control circuits (except the driving circuits of the printing mechanism itself).

It shall be possible during pattern approval and other verifications to check that the checking facility of the printing device is functioning by an action simulating a printing fault, such as using a test-button.

Where the action of the checking facility is a warning, this shall be given on or by the ancillary device concerned.

4.3.6 Checking facilities for the associated measuring instruments

Associated measuring instruments shall include a checking facility of type P. The aim of this checking facility is to ensure that the signal given by these associated instruments is inside a pre-determined measuring range.

Examples:

- four wire transmission for resistive sensors,
- frequency filters for density meters,
- control of the driving current for 4–20 mA pressure sensors.

5 Requirements specific to certain types of measuring systems

5.1 Fuel dispensers

Except where otherwise specified, the requirements in this subclause do not apply to LPG dispensers.

5.1.1 By design, the ratio between the maximum flowrate and the minimum flowrate for these systems shall be at least ten; on site, this ratio may be smaller provided that it is not less than five.

5.1.2 When the measuring system includes its own pump, a gas elimination device shall be installed, immediately upstream of the meter inlet. Where a gas indicator is fitted, it shall not have a venting device as mentioned in 2.11.

5.1.3 When the measuring system is intended for installation in a centrally pumped system, or for a remote pump, the general provisions in 2.10 shall be applied.

If it is not intended to install a gas elimination device the manufacturer or installer has to prove that there is no risk of air intake or gas release. In this case the minimum level in the storage tank must be automatically secured and any leakage shall be checked (see also 2.10.2).

5.1.4 Fuel dispensers shall be equipped with a device for resetting the volume indicating device to zero.

The minimum height for the figures of the resettable volume indicator is 10 mm.

If these systems also include a price indicating device, this indicating device shall be fitted with a zero resetting device. The minimum height for the price indicator remains 4 mm (see 3.2.2.6).

5.1.5 When only one nozzle can be used during a delivery, and after the nozzle has been replaced, the next delivery shall be inhibited until the indicating device has been reset to zero.

When two or more nozzles can be used simultaneously or alternately, and after the utilized nozzles have been replaced, the next delivery shall be inhibited until the indicating device has been reset to zero. Moreover, by design, the provisions in the first paragraph of 2.16.1 shall be fulfilled.

The above requirements do not apply when an auxiliary hand pump is used.

5.1.6 Measuring systems having a maximum flowrate not greater than 3.6 m³/h shall have a minimum delivery not exceeding 5L.

5.1.7 When the measuring system is fitted with a ticket printing device which is subject to control, this printing device shall comply with the relevant requirements in 3.4. In addition, any printing operation shall prevent the continuation of the delivery until a reset to zero has been performed. However, the printing operation shall not change the quantity indicated on the indicating device.

5.1.8 Fuel dispensers shall be interruptible.

5.1.9 In addition to requirements in 4.2.2, electronic fuel dispensers shall be such that the minimum duration of operation of the display shall be either:

- at least 15 min continuously and automatically after the failure of the principal electrical supply, or
- a total of at least 5 min in one or several periods controlled manually during one hour after the failure.

Note: If a test during pattern approval is necessary to verify that the fuel dispenser fulfills this requirement, the instrument has to be supplied with electric power normally for the 12 hours which preceded the test. Before this supply the battery (if provided) may be unloaded.

In addition, fuel dispensers shall be designed so that an interrupted delivery cannot be continued after the power supply device has been re-established if the power failure has lasted more than 15 s.

5.1.10 Electronic fuel dispensers shall be such that the delay time between the measurement value and the corresponding indicated value shall not exceed 500 ms.

Several fuel dispensers may have a common indicating device if and only if the first provision in 2.9.6 is met.

5.1.11 The checking of the operation of the calculator, as described in 4.3.3.1, shall be performed at least once for each delivery.

5.1.12 It is not required to display volumes, and prices if applicable, that correspond to a small number of scale intervals at the beginning of the delivery, and to start the display with that volume and the corresponding price.

The volume thus hidden shall not be greater than two times the minimum specified volume deviation. The hidden price shall not be greater than the price corresponding to that volume.

5.2 Measuring systems on road tankers for the transport and delivery of liquids of low viscosity (≤ 20 mPa.s) and stored at atmospheric pressure, with the exception of potable liquids

5.2.1 The provisions hereafter apply to measuring systems mounted on road tankers or on transportable tanks.

5.2.2 Tanks equipped with measuring systems may comprise one or more compartments.

5.2.3 The compartments of road tankers shall be fitted with an anti-swirl device, except when the measuring system is fitted with a gas separator which complies with 2.10.8.

5.2.4 When a tank comprises more than one compartment, each compartment shall be provided with an individual (manual or automatic) closing device in each outlet line.

5.2.5 In conformity with national regulations on their use, each measuring system shall be allocated to a specific product or to a range of products for which the meter has been approved.

The pipework shall, as far as possible, be designed so that products cannot become mixed in the measuring system.

5.2.6 Subject to the requirements in 2.16, a measuring system mounted on a road tanker may include empty or full hoses or both. Where several hoses are intended to operate alternatively, the changing of the delivery path shall be impossible during a measurement operation. To this end, the change of the delivery path may be linked to the resetting to zero of the volume indicating device.

5.2.7 The volume indicating device shall include a zero resetting device complying with 3.2.4.

When the measuring system is fitted with a ticket printing device, any printing operation shall prevent the continuation of the delivery until a reset to zero has been performed, except for printing devices determining the delivered volume by means of two consecutive indications.

5.2.8 Measuring systems mounted on road tankers may be designed to operate by pump only, or by gravity only, or with the choice of either pump or gravity, or by gas pressure.

5.2.8.1 Measuring systems fed by pump only may operate either empty hose or full hose.

5.2.8.1.1 If there is a risk that the requirements in 2.10.2 related to the absence of air or gas cannot be complied with, the meter shall have one of the following gas elimination devices upstream of it:

- a suitable gas separator conforming to 2.10.8,
- a special gas extractor, conforming to 2.10.9,
- a gas extractor, conforming to 2.10.9.

When, in a measuring system, the pressure at the outlet of the meter can be lower than the atmospheric pressure while remaining higher than the saturated vapor pressure of the measured product, the above devices shall be combined with an automatic system for slowing down and stopping the flow to prevent any air from entering the meter.

When the pressure at the outlet of the meter cannot be lower than atmospheric pressure (this is especially the case for systems operating solely full hose), the use of automatic devices for slowing down and stopping the flow is not required.

5.2.8.1.2 The special gas extractor shall be fitted with a sight glass.

5.2.8.2 Measuring systems operating solely by gravity shall comply with the following requirements.

5.2.8.2.1 The equipment shall be so constructed that the total contents of the compartment(s) can be measured at a flowrate greater than or equal to the minimum flowrate of the measuring system.

5.2.8.2.2 If there are connections with the gas phase in the tank of the road tanker, appropriate devices shall prevent any gas from entering the meter.

5.2.8.2.3 The requirements in 2.10.3 concerning non-pumped flow shall apply.

A pump downstream of the transfer point for increasing the flowrate may be authorized if the foregoing provisions are complied with. This pump shall not cause a fall in pressure in the meter.

5.2.8.2.4 For measuring systems which include a manual release to the atmosphere immediately downstream of the transfer point, a gas indicator is mandatory.

5.2.8.3 Measuring systems capable of being operated either by gravity or by pump shall comply with the requirements in 5.2.8.1 and 5.2.8.2.

5.2.8.4 Measuring systems operated by means of gas pressure may operate empty hose or full hose. The pipework which links the meter to the device intended to prevent any gas from entering the meter as specified in point 2.10.3 shall have no constriction or component likely to cause a pressure loss which could generate gas pockets by releasing the gas dissolved in the liquid.

These systems shall include a pressure gauge which indicates the pressure in the tank. The dial of this gauge shall indicate the range of permissible pressures.

5.3 Measuring systems for the unloading of ships' tanks and of rail and road tankers using an intermediate tank

5.3.1 Measuring systems designed to measure volumes of liquids during the unloading of ships' tanks and of rail and road tankers may include an intermediate tank in which the liquid level determines the transfer point. This intermediate tank may be designed to ensure the elimination of gas.

The cross section of the intermediate tank shall be such that a volume equal to the minimum specified volume deviation corresponds to a difference in level of at least 2 mm.

5.3.2 In the case of road and rail tankers, the intermediate tank shall automatically ensure a constant level, visible or detectable, at the beginning and at the end of the measurement operation. The level is considered to be constant when it settles within a range corresponding to a volume of no more than the minimum specified volume deviation.

5.3.3 In the case of ships' tanks, it is not necessary to provide for the automatic maintenance of a constant level. Where such a provision is not made, it shall be possible to measure the contents in the intermediate tank.

If the ships' tank is unloaded by means of pumps located in the bottom of the ship, the intermediate tank may be used only at the beginning and at the end of the measurement operation.

5.4 Measuring systems for liquefied gases under pressure (other than LPG dispensers)

5.4.1 Only full hose measuring systems are authorized.

5.4.2 A pressure maintaining device, located downstream of the meter, shall ensure that the product in the meter remains in a liquid state during the measurement. The necessary pressure may be maintained either at a fixed value or at a value adjusted to suit the measurement conditions.

5.4.2.1 When the pressure is maintained at a fixed value, this value shall be at least equal to the vapor pressure of the product at a temperature 15 °C above the highest possible operating temperature. It shall be possible to protect the adjustment of the pressure maintaining device with a seal.

5.4.2.2 When the pressure is adjusted to suit the measurement conditions, this pressure shall exceed the vapor pressure of the liquid during the measurement by at least 100 kPa (1 bar). This adjustment shall be automatic.

5.4.2.3 For stationary measuring systems for industrial use, the competent metrology service may authorize manually-adjustable pressure maintaining devices. The pressure at the meter outlet shall then be at least equal to the vapor pressure of the product at a temperature 15 °C above the temperature of the measurement. It is then necessary to attach a diagram to the measuring system, giving the vapor pressure of the measured product as a function of its temperature. If it is anticipated that these measuring systems may have to operate unsupervised over long periods, the temperature and pressure shall be registered continuously by means of appropriate instruments.

5.4.3 A gas elimination device shall be fitted upstream of the meter. However, if it is demonstrated that no vapor release will occur during measurements a gas elimination device is not mandatory. This demonstration shall include tests under the worse conditions.

5.4.3.1 The gas separator shall comply with the general requirements in 2.10.1, either for the liquefied gas itself or for a liquid of higher viscosity.

However, because of the low viscosity of liquefied gases and due to the difficulty of control, it is accepted that when the length of the pipework linking the meter to the feed tank does not exceed 25 m, a gas separator may be approved if its useful volume is at least equal to 1.5 % of the volume delivered in one minute at maximum flowrate. When the length of this pipework exceeds 25 m, the useful volume of the gas separator shall be at least equal to 3 % of the volume delivered in one minute at maximum flowrate.

The gas outlet pipe of the separator may be connected to the space in the feed tank which contains the gaseous phase, or to an independent pressure maintaining device set to a pressure from 50 to 100 kPa (0.5 to 1 bar) lower than the pressure at the meter outlet. This pipe may incorporate a shut-off valve, which meets the requirements in 2.10.5.

5.4.3.2 The volume of the condenser tank depends on the volume of the pipework between the supply tank valve and the pressure maintaining valve, downstream of the meter. The volume of this condenser tank shall be at least equal to twice the reduction in volume of the liquid which is likely to occur between these valves if the temperature drops by a value conventionally fixed at 10 °C for exposed pipes and 2 °C for insulated or underground pipes.

To calculate the contraction, the coefficient of thermal expansion shall be rounded to 3×10^{-3} per degree Celsius for propane and propylene and 2×10^{-3} per degree Celsius for butane and butadiene. For other products with a high vapor pressure, the values of the coefficient to be adopted shall be specified by the competent metrology service.

The condenser tank shall be fitted with a manual blow off valve. It shall be fitted at the high point in the pipework of the measuring system of which it is part.

The volume resulting from the above calculation may be divided between several condenser tanks located at high points in the pipework.

5.4.4 A thermometer well or, when this thermometer well is not imposed by specific professional practices, another means for measuring temperature, shall be provided close to the meter. The thermometer used shall have a scale interval not exceeding 0.5 °C and shall be verified.

Provisions shall be made for fitting a pressure measuring device between the meter and the pressure maintaining device. This measuring device shall be available for verification. If necessary, provisions for sealing shall be made.

5.4.5 When the volume is measured using a system mounted on a road tanker, any connection between the gaseous phases of the vehicle's tank and of the receiving tank is prohibited unless it is essential for completing a measurement, in which case a non-return valve is mandatory.

For other measuring systems for liquefied gas, such connections are permitted when the volumes of gas transferred via these connections are measured by means of suitable measuring instruments.

5.4.6 Safety valves may be incorporated in measuring systems in order to prevent abnormally high pressures. If they are located downstream of the meter, they shall open to the atmosphere or be connected to the receiving tank.

In no case shall the safety valves located upstream of the meter be connected to the valves located downstream by pipes which bypass the meter.

5.4.7 When the conditions of operation require the use of detachable hoses, these hoses shall remain full if their volumes are greater than the minimum specified volume deviation.

Detachables full hoses shall be fitted with special connections for full hoses, so-called couplers or self-sealing valves. Manually operated blow-off devices shall be provided at the ends of these hoses, if necessary.

5.4.8 The control valve of the double closing device mentioned in 2.16.3 for pipework bypassing the meter, if provided, may be closed for safety reasons. In this case, any leakage shall be monitored by a pressure gauge located between the two shut off valves or by any other equivalent system.

5.4.9 For measuring systems mounted on road tankers the volume indicating device and its printing device, if provided, shall comply with the requirements in 5.2.7.

5.4.10 The provisions in 5.4 also apply for measuring systems for liquefied carbon dioxide with the following exceptions:

- only empty hose measuring systems are authorized (see 5.4.1),
- the connection between the gaseous phases of the vehicle's tank and of the receiving tank is authorized if (i) a device is installed to allow compensation of the delivered quantity by an amount relating to the quantity of vapor returned in the gas line, or (ii) compensation is made by automatic or manual calculation. However, in both cases, flow from the delivery tank to the receiving tank by means of the gas return line shall be securely prevented (see 5.4.5),
- the requirements of 5.4.7 are not mandatory for these systems.

5.5 Measuring systems for milk

5.5.1 The following requirements apply to transportable measuring systems which are mounted on road tankers and used for the collection of milk, to fixed measuring systems used for the reception of milk at the dairy, and to fixed or transportable measuring systems used for the delivery of milk.

5.5.2 The transfer point in reception installations is defined by a constant level in a tank upstream of the meter. It must be possible to check this constant level before and after each measurement. The level shall be established automatically.

5.5.2.1 When the meter is fed by means of a pump, the constant level tank may be placed either upstream of the pump or between the pump and the meter.

5.5.2.1.1 If the constant level tank is placed upstream of the pump, the tank itself may be fed by gravity, by emptying milk churns, by means of an auxiliary pump or by means of a vacuum system.

If the milk is introduced by means of a pump or a vacuum system, a gas elimination device is necessary. This device may be combined with the constant level tank.

5.5.2.1.2 If the constant level tank is placed between the pump and the meter, this tank shall ensure that gas is eliminated.

5.5.2.2 Notwithstanding the requirements of 2.13.3, the meter may be fed by means of a vacuum system. In this case, the pressure inside the pipework connecting the constant level tank to the meter will be lower than atmospheric pressure and the tightness of the joints of this connection must be particularly well ensured. It must be possible to check the tightness and a notice plate drawing attention to this checking shall be provided.

5.5.2.3 In all installations for reception, the pipework upstream of the constant level device shall empty completely and automatically under the rated operating conditions.

5.5.2.4 The constant level is monitored by means of a sight glass or a level indicating device. The level is considered to be constant when it settles within a range defined by two marks at least 15 mm apart and corresponding to a difference in volume of no more than twice the minimum specified volume deviation.

5.5.2.5 If, in order to meet the above condition, devices for reducing the flowrate are incorporated in the measuring system, the flowrate during the period of reduced flowrate shall be at least equal to the minimum flowrate of the meter.

5.5.2.6 If, in a reception installation at a dairy, the measured liquid flows to a level lower than that of the meter, a device shall automatically ensure that the pressure at the outlet of the meter remains above atmospheric pressure.

5.5.2.7 If a volume of liquid is required to fill the measuring system prior to the first measurement, it shall be indicated on the data plate of the measuring system so that it can be taken into account, by calculation, in the first measurement of a reception period. The first volume measured by the measuring system during a reception period shall be equal to or greater than the volume which is necessary for the complete filling of the measuring system.

5.5.3 Measuring systems used for delivery shall comply with the general requirements in clause 2 and with those in clause 3.

5.5.4 Notwithstanding the general requirements in 2.10 concerning the elimination of air or gases, the gas elimination devices shall comply with the requirements in 2.10.1 solely under the conditions of use, i.e. with entry of air at the beginning and end of each measuring operation of delivery.

The mounting of delivery installations shall be such that the pressure of the liquid at the level of the joint to the supply tank is always greater than atmospheric pressure.

5.5.5 The volume indicating device of a transportable measuring system and its printing device, if provided, shall comply with the requirements in 5.2.7.

5.6 Measuring systems on pipeline and systems for loading ships

5.6.1 The ratio between the maximum flowrate and the minimum flowrate of the meter of the measuring system may be less than the value specified in the relevant paragraph in 3.1.1.3.

In this case, the measuring system shall be fitted with an automatic checking device to verify that the flowrate of the liquid to be measured is within the restricted measuring range of the measuring system.

This checking device shall be of type P and shall meet the requirements in 4.3.1.2.

The maximum and minimum flowrates may be determined in relation to the liquid to be measured and manually introduced into the calculator.

5.6.2 Prevention of gas flow

The measuring system shall be provided with a means of eliminating any air or gas contained in the liquid unless the entry of air into the liquid or release of gas from the liquid is prevented by the configuration of the pipework or by the arrangement and operation of the pump(s).

5.6.3 Special conditions of installation

Reverse flow of the liquid to be measured in the measuring system shall be prevented by a suitable device, unless otherwise approved.

5.6.4 Sampling device

The measuring system may include a sampling device intended to determine the properties of the liquid to be measured.

It is not necessary to take into account the volume of the sample in the results of the measurement if this sample is less than 0.1 times the maximum permissible error of the measuring system.

5.6.5 Testing devices

Measuring systems in pipelines should be provided with devices allowing verification of the systems in situ. However, this principle may be waived provided that:

- the meters are verified on a control test station with liquids having the same characteristics as those to be measured at the place of installation. The verification is carried out on the measurement transducer only, associated with a compatible and equivalent indicating device, provided that all the elements having a direct mechanical link with the measurement transducer and being able to influence the measurement are verified at the same time,
- the meters benefiting from this exemption shall be subject to periodic calibration controlled and fixed by the metrology service, and
- to complete the verification, the measuring systems concerned shall be subjected to a qualitative check of function and installation, in situ.

Subject to this exemption, the measuring systems shall be constructed so that a standard of appropriate size can be fitted for testing the meters. When a test can only be carried out with the pumps running, which normally does not allow for testing with the meter stopped at the start and at the end of the test, the standard shall be suitable for continuous operation (for example, volume standard with a flow diverting mechanism, pipe prover etc.).

Moreover, these capacities shall represent at least 10 000 scale intervals of the indicating device of the meter to be verified or of the auxiliary indicating device used for the test or 10 000 electrical pulses of the measurement transducer. However, a lower capacity may be permitted if a visual or automatic interpolation allows one to ascertain the indication of the meter with an error smaller than or equal to one per ten thousand of this capacity.

Furthermore, it shall be possible to carry out a metrological test of the associated measuring instruments which may be incorporated and which aim at measuring density, viscosity, pressure and temperature, under actual operating conditions.

5.7 Fuel dispensers for liquefied gases under pressure (LPG dispensers)

5.7.1 Requirements in 5.1.1, 5.1.4 and 5.1.7 to 5.1.12 are applicable to LPG dispensers for motor vehicles. However, the ratio between the maximum flowrate and the minimum flowrate shall be at least five by design.

5.7.2 Requirements in 5.4.1, 5.4.2, 5.4.2.1, 5.4.2.2, 5.4.3, 5.4.3.1 and 5.4.3.2 are applicable to LPG dispensers for motor vehicles.

5.7.3 A thermometer well may be provided close to the meter. When it is not provided the legal metrology authority may require that the manufacturer or the owner of the measuring system provide an equivalent means for measuring temperature. The thermometer used shall have a scale interval not exceeding 0.5 °C and shall be verified.

Provision shall be made for fitting a pressure measuring device between the meter and the pressure maintaining device. This measuring device shall be available for verification. If necessary, provision for sealing shall be made.

5.7.4 Connection between the gas phases of the feed tank and of the vehicle's tank is prohibited.

5.7.5 When only one nozzle can be used during a delivery, and after the nozzle has been replaced, the next delivery shall be inhibited until the indicating device has been reset to zero.

When two or more nozzles can be used simultaneously or alternately, and after the utilized nozzle have been replaced, the next delivery shall be inhibited until the indicating device has been reset to zero. Moreover, by design, the provisions in the first paragraph of 2.16.1 shall be fulfilled.

Moreover, in both cases, when the flow is stopped by emergency means and a predetermined delay is exceeded, the current delivery shall be stopped and the next delivery shall be preceded by a reset to zero.

5.7.6 A non-return valve, located between the gas elimination device and the meter, is mandatory. The pressure loss caused by it shall be sufficiently low to be considered negligible.

5.7.7 Hoses shall be fitted with special connections for full hoses, so-called couplers or self-sealing valves.

5.7.8 Safety features shall not affect the metrological performance.

5.7.9 ~~When the measuring system is provided with a conversion device, it shall be possible~~ to verify separately the indications of volume at measuring conditions and associated measuring instruments.

5.7.10 Closing valves in vapor return lines shall automatically result in stopping the delivery or preventing the start of the next delivery, unless these valves have been sealed in the open position.

5.7.11 The construction of the nozzle shall be such that, at the moment of coupling or uncoupling, the loss of liquid does not exceed the minimum specified volume deviation.

5.8 Measuring systems intended for the refuelling of aircraft

The requirements of this subclause also apply to the refuelling of helicopters.

5.8.1 General

5.8.1.1 Measuring systems intended for refuelling aircraft are full hose measuring systems.

5.8.1.2 The gas elimination device function may be performed by a microfilter water elimination device provided that provisions in 2.10 are fulfilled.

5.8.1.3 They shall be interruptible measuring systems.

5.8.2 Stationary measuring systems

5.8.2.1 The requirements applicable to fuel dispensers apply to stationary measuring systems intended for the refuelling of aircraft, except those in 5.1.1.

5.8.2.2 These systems may include their own pumps or be designed for installation in a centrally pumped system.

5.8.2.3 The microfilter-water elimination device shall be fitted upstream of the gas elimination device when these devices are separate one from another.

5.8.3 Mobile measuring systems

5.8.3.1 General

5.8.3.1.1 If more than one transfer point is provided, interlocks should prevent the usage of two or more together unless the arrangement is such that it would be difficult to use them on different aircrafts at the same time.

5.8.3.1.2 They may be designed for defuelling aircraft provided that the connecting point for defuelling is located upstream of the gas elimination device. A weir-type sight glass is not mandatory.

Interlocks may also be necessary to prevent bypassing metered liquid through the return line back to the supply tank while delivering fuel to the aircraft.

5.8.3.1.3 Where the microfilter-water elimination device may be used to perform the function of the gas elimination device, it may be verified by an examination of documents only if provisions in 2.10 are fulfilled.

5.8.3.1.4 Each installation shall be provided with or accompanied by:

- instructions for use,
- a liquid circulation plan,
- a description of necessary operations for use,
- a description of control and connecting devices positions related to their use.

5.8.3.2 Aircraft refuelling tanker measuring systems

The requirements in 5.2.2, 5.2.3, 5.2.4, 5.2.6, 5.2.7 and 5.2.8.1 apply.

Note: For good practice in the use of the system, when the aircraft refuelling tanker measuring system is fitted with a device used to perform the gas extractor or special gas extractor function, a manometer should be provided upstream of the pump in order to detect depressions when they occur. Its indications should be easily visible by the operator.

5.8.3.3 Aircraft hydrant measuring systems

5.8.3.3.1 The gas elimination device may be a device performing the function of a gas extractor when the underground pipe:

- is designed for easy elimination of the air contained in the pipe with appropriate devices,
- is fitted with special connecting devices for full hoses,
- is supplied so that, in designed supply conditions, no gaseous formation can occur or enter the underground pipe.

5.8.3.3.2 When the aircraft hydrant measuring system is equipped with a device for froth recovery and reinjection, it shall be located upstream of the gas elimination device and it shall not permit permanent introduction of gas into the meter.

5.8.3.3.3 Depressurization valves for the hoses so that connection and disconnection can be easily made, shall be accompanied with interlocks to prevent metered liquid from being diverted.

5.9 Blend dispensers

5.9.1 The requirements in 5.1.1 to 5.1.4 and 5.1.6 to 5.1.12 are applicable to both parts of the multigrade-dispenser and to the gasoline part of the gasoline-oil-dispenser. However, by design, the ratio between the maximum flowrate and the minimum flowrate may be at least five in the case of multigrade-dispensers.

5.9.2 When only one nozzle can be used during a delivery, and after the nozzle has been replaced, the next delivery shall be inhibited until the indicating device has been reset to zero.

When two or more nozzles can be used simultaneously or alternately, and when the utilized nozzles have been replaced, the next delivery shall be inhibited until the indicating device has been reset to zero. Moreover, by design, the provisions in the first paragraph of 2.16.1 shall be fulfilled.

5.9.3 The requirements in 5.9.4 through 5.9.8 do not apply if the designations of the various mixtures do not allow conclusions to be drawn concerning the ratio of volumes of the two components.

Examples for such designations:

- number of stars (2, 3, 4 stars),
- octane-number (92, 95, 98 octane),
- two-stroke-mixture (without designation such as 5 %).

Moreover, the requirement in 5.9.4 or 5.9.5 only applies where the measuring system provides the indication of the mixed volume and the price of the mixture depends on the blending ratio. It does not apply where the measuring system provides:

- an indication of the mixed volume and the price does not depend on the blending ratio, or,
- a volume indication for each component of the mixture and does not provide an indication of the mixed volume.

To permit compliance with the requirement in 5.9.4 or 5.9.5 to be verified, it is necessary:

- for multigrade-dispensers to measure the volumes of both components,
- for gasoline-oil-dispensers to measure either the volumes of oil and gasoline or the volumes of oil and mixture,
- for both types to make the separate collection of both components feasible during verification.

5.9.4 The accuracy of the blending ratio for multigrade-dispensers shall be as follows.

The designations of the various mixtures being indicated as the ratio of volumes of the two components (for example 1:1), the real ratio of the volumes of two components shall be within the limits of $\pm 5\%$, i.e. the real ratio $k_{\text{real}} = V_2/V_1$ of volumes of both components determined during the verification shall be equal to the nominal (indicated) ratio k_{nom} , within the limits:

$$k_{\text{min}} = k_{\text{nom}} - 0.05 k_{\text{nom}} \quad \text{and} \quad k_{\text{max}} = k_{\text{nom}} + 0.05 k_{\text{nom}}$$

Examples:

Designation	3:1	1:1	1:3
k_{nom}	0.333	1.00	3.00
k_{min}	0.316	0.95	2.85
k_{max}	0.350	1.05	3.15

5.9.5 The accuracy of the blending ratio for gasoline-oil-dispensers shall be as follows.

If V_1 is the volume of the minority component in the mixture and V_2 the volume of the majority component, the real volumetric ratio related to the minority component,

expressed as a percentage $[T = 100 \times V_1 / (V_1 + V_2)]$, shall be equal to the nominal ratio within a limit of plus or minus:

- 5 % in relative value,
- 0.2 % absolute, whichever is greater.

In other words, T being the real volumetric ratio as a percentage, and T_{nom} the nominal volumetric ratio as a percentage, the following must be satisfied:

$$|T - T_{nom}| / T_{nom} \leq 0.05$$

if the nominal volumetric ratio is at least 4 %, and

$$|T - T_{nom}| \leq 0.2 \%$$

if the nominal volumetric ratio is less than 4 %.

5.9.6 If the blend dispenser is capable of delivering more than one mixture with the same nozzle, the installation of two hoses and a special blending device close to the transfer point is required.

If the blend dispenser can deliver only one mixture per nozzle, the blending device may be installed inside the dispenser, using a single hose per nozzle.

5.9.7 If the blend dispenser is capable of delivering one or both single components (in addition to the mixtures) with a common nozzle, a device shall prevent the liquid flow through the unused part of the blend device.

5.9.8 The lubricating oil part of a gasoline-oil-dispenser shall be designed so as to prevent air bubbles in the oil passing through the oil measuring device. There shall also be a device to detect the presence of oil. In the absence of oil, delivery has to be stopped by means, e.g. of:

- an intermediate oil reservoir and a device which stops the delivery when the oil reservoir is empty,
- a pressure detecting device which stops the delivery in the case of an oil pressure drop.

5.10 Self-service arrangement with fuel dispensers

The following requirements apply to measuring systems covered by 5.1, 5.7 or 5.9 when fitted with self-service arrangements.

5.10.1 General requirements

5.10.1.1 Marking, sealing and connection of the components are ~~left to national regulations~~

5.10.1.2 Where the self-service device serves two or more dispensers, each dispenser shall be provided with a dispenser identification number that shall accompany any primary indication provided by the self-service device.

5.10.1.3 The primary indications on indicating devices and printing devices of the self-service arrangement shall not indicate any mutual differences.

The scale intervals of the primary indication on indicating devices and the printing devices and memory devices of the self-service arrangement shall be the same.

5.10.1.4 Printing devices on the self-service arrangement shall not reproduce the indications of a dispenser as the difference between two printed values.

5.10.1.5 Indication of information that is not subject to metrological control is allowed, provided that it cannot be confused with metrological information.

5.10.1.6 The control device of the self-service device should be capable of indicating the status of the dispensers (e.g. running, authorized or unauthorized) that are connected to the self-service device and in the case of multiple modes of service and/or type of payment also that particular status of the measuring system.

5.10.1.7 A change of the type of payment and/or mode of operation shall not be effective before the end of the current measurement operation.

5.10.1.8 The self-service arrangement, including provisions related to clearly defined methods of operation, shall be such that at least one primary indication for the benefit of the customer must be available at least up to the settlement of the transaction to enable the delivered quantity and the price to pay to be checked.

5.10.1.9 In the case of a self-service arrangement that totalizes the delivered volumes for different registered customers over the course of time, the minimum measured quantity is not affected by the scale interval used for such totalizations.

5.10.2 Attended service mode

If the dispenser indicating device provides the only primary indication, provisions shall be made to inform the customer that the next authorization of a particular dispenser can only be given by the supplier after settlement of the current transaction.

5.10.2.1 Attended post-payment

5.10.2.1.1 Where the self-service arrangement includes a device that provides an additional primary indication (additional to those of the indicating device of the dispenser), it shall consist of at least one installation for the reproduction of the volume and/or the price indicated by the dispenser indicating device, consisting of:

- a printing device for the issue of a receipt to the customer, or
- an indicating device for the benefit of the supplier together with a display for the benefit of the customer.

Note: As a consequence of 3.4.7, the reproduction of the volume and price is necessary when the dispenser can be authorized before the settlement of the transaction.

5.10.2.1.2 For self-service devices with temporary storage (temporary storage mode) of measurement data of dispensers the following requirements apply:

- a) temporary storage of measurement data shall be restricted to one delivery for each dispenser,
- b) the primary indication shall be accompanied by a clear mark representing the sequence. For example, the number 1 or 2 or the letter A or B,
- c) when a primary indication of the self-service device is out of service, the self-service arrangement may continue its operation provided that it no longer uses any temporary storage, and that the dispenser indicating device remains the primary indication.

5.10.2.1.3 Where the mandatory primary indication for the benefit of the customer is provided by a device in the form of a separate constructional unit and this unit becomes uncoupled, or if the checking facilities detect a malfunction, the temporary storage mode shall be prohibited and the dispenser indicating device remains the primary indication.

5.10.2.2 Pre-payment in attended service mode

5.10.2.2.1 The requirements of 3.6 are applicable.

5.10.2.2.2 A printed or hand-written receipt of the pre-paid amount shall be provided.

5.10.3 Unattended service mode

5.10.3.1 General

5.10.3.1.1 The self-service arrangement shall provide additional primary indications by means of:

- a printing device for the issue of a receipt to the customer, and
- a device (printing or memory device) on which measurement data are registered for the benefit of the supplier.

5.10.3.1.2 When the printing devices or memory device, as required by 5.10.3.1.1, are not able to provide any indication or become unserviceable, the customer shall be clearly warned by automatic means before the operation commences.

Passing from attended to unattended service mode shall not be possible before correct operation of the arrangement is concluded as feasible by the checking facilities, including compliance with the above provision.

5.10.3.1.3 Where the self-service arrangement is used by registered customers, the provisions of 5.10.3.1.1 and 5.10.3.1.2 do not apply to measurements related to such customers. An additional individual volume totalizer is considered to provide a primary indication.

5.10.3.1.4 Micro-processors, which upon disturbance or interference influence the measurement operation, shall be equipped with means for controlling the continuity of the processor program and for ensuring the discontinuation of the current delivery when the continuity of the processor program is no longer ensured.

The next effective acceptance of notes, cards or other equivalent mode of payment shall only take place if the continuity of the processor program is re-established.

5.10.3.1.5 When a power supply failure occurs, the delivery data shall be memorized. The requirements of 5.1.9 apply.

5.10.3.2 Delayed-payment

The printed and/or memorized indications as mentioned in 5.10.3.1 shall contain sufficient information for further checking and at least, the measured quantity, the price to pay and information to identify the particular transaction (e.g. the dispenser number, location, date, time).

5.10.3.3 Pre-payment in unattended service mode

5.10.3.3.1 Following the termination of each delivery, the printed and/or memorized indications as intended in 5.10.3.1 shall be made available, clearly indicating the amount which has been pre-paid and the price corresponding to the liquid obtained.

These printed and/or memorized indications may be divided into two parts as follows:

- a) one part provided prior to the delivery on which the pre-paid amount is shown and recognizable as such,
- b) one part provided following the termination of delivery, provided that it is clear from the information provided on both parts that they are related to the same delivery.

5.10.3.3.2 The requirements of 3.6 are applicable.

5.11 Other self-service arrangements

Measuring systems, especially those for loading road or rail tankers, may be designed in such a way that the transaction is not settled when the customer leaves the loading site, in implicit agreement with the supplier.

In this case, national or international regulations may prescribe that the self-service arrangement provide additional primary indications by means of:

- a printing device for the issue of a receipt to the customer, and
- a device (printing or memory device) on which measurement data are registered for the benefit of the supplier.

The printed and/or memorized indications shall contain sufficient information for further checking and at least the measured quantity and information to identify the particular transaction (e.g. the system number, location, date, time).

Moreover, after a delivery, measuring systems shall not be capable of being reset to zero and authorized until measurement data are memorized or printed out.

6 Metrological control

When a test is conducted, the expanded uncertainty of the determination of errors on indications of volume or mass shall be less than one-fifth of the maximum permissible error applicable for that test on pattern approval and one-third of the maximum permissible error applicable for that test on other verifications. The estimation of expanded uncertainty is made according to the *Guide to the expression of uncertainty in measurement* (1995 edition) with $k = 2$.

The working standards and their use ~~will be the subject of specific International Recommendations.~~

6.1 Pattern approval

6.1.1 General

Measuring systems subject to legal metrology control shall be subject to pattern approval. In addition, the constituent elements of a measuring system, mainly those listed below, and the sub-systems which include several of these elements, may be subject to separate pattern approval:

- meter,
- transducer,
- gas separator,

- gas extractor,
- special gas extractor,
- electronic calculator (including the indicating device),
- conversion device,
- ancillary devices providing or memorizing measurements results,
- pre-setting device,
- densitometer,
- temperature sensor.

Note: ~~In some countries, the expression “pattern approval” can be reserved for complete measuring systems. In this case, it is advisable that patterns of constituent elements be submitted to a procedure similar to pattern approval, making it possible to certify the conformity of the pattern of a constituent element to the regulation.~~

The constituent elements of a measuring system shall comply with the relevant requirements even when they have not been subject to separate pattern approval (except, of course, in the case of ancillary devices that are exempted from the controls).

Unless otherwise specified in this Recommendation, a measuring system should fulfill the requirements without adjustment of the system or of its devices during the course of the tests. If an adjustment is carried out, this condition shall still be considered as valid.

6.1.2 Documentation

6.1.2.1 The application for pattern approval of a measuring system or of a constituent element of a measuring system shall include the following documents:

- a description giving the technical characteristics and the principle of operation,
- a drawing or photograph,
- a list of the components with a description of their constituent materials when this has a metrological influence,
- an assembly drawing with identification of different components,
- for measuring systems, the references of the approval certificates of the constituent elements, if any,
- for measuring systems and meters fitted with correction devices, a description of how the correction parameters are determined,
- a drawing showing the location of seals and verification marks,
- a drawing of regulatory markings.

6.1.2.2 In addition, the application for pattern approval of an electronic measuring system shall include:

- a functional description of the various electronic devices,
- a flow diagram of the logic, showing the functions of the electronic devices,
- any document or evidence which shows that the design and construction of the electronic measuring system comply with the requirements of this Recommendation, in particular subclause 4.3.

6.1.2.3 The applicant shall provide the body responsible for the evaluation with an instrument representative of the final pattern.

Other specimens of the pattern may be considered necessary by the body responsible for the pattern evaluation to estimate the reproducibility of the measurements (see 6.1.5.2.4).

6.1.3 Pattern approval certificate

The following information shall appear on the pattern approval certificate:

- name and address of the recipient of the approval certificate,
- name and address of the manufacturer, if it is not the recipient,
- type and/or commercial designation,
- principal metrological and technical characteristics,
- pattern approval mark,
- period of validity,
- environmental classification, if applicable (see annex A.1),
- information on the location of marks for pattern approval, initial verification and sealing (e.g. picture or drawing),
- list of documents accompanying the pattern approval certificate,
- specific remarks.

When applicable, the version of the metrological part of the evaluated software shall be indicated in the pattern approval certificate or in its annexes (technical file).

6.1.4 Modification of an approved pattern

6.1.4.1 The recipient of the pattern approval shall inform the body responsible for the approval of any modification or addition which concerns an approved pattern.

6.1.4.2 Modifications and additions shall be subject to a supplementary pattern approval when they influence, or are likely to influence, the measurement results or the instrument's regulatory conditions of use.

The body having approved the initial pattern shall decide to which extent the examinations and tests described below shall be carried out on the modified pattern in relation with the nature of the modification.

6.1.4.3 When the body having approved the initial pattern judges that the modifications or additions are not likely to influence the measurement results, this body allows the modified instruments to be presented for initial verification without granting a supplementary pattern approval.

A new or supplementary pattern approval must be issued whenever the modified pattern no longer fulfills the provisions of the initial pattern approval.

6.1.5 Pattern approval of a meter or of a measurement transducer

6.1.5.1 A pattern approval may be given for a complete meter; it may also be given for the measurement transducer only (as defined in T.1.2) when this is intended to be connected to different types of calculators.

The following examinations and tests shall be carried out on the meter alone or on the measurement transducer when it is the subject of a separate application for pattern approval. They may also be carried out on the whole measuring system.

Tests are normally carried out on the complete meter, fitted with an indicating device, with all the ancillary devices and with the correction device, if any. However, the meter subject to testing need not be fitted with its ancillary devices when the latter are not likely to influence the accuracy of the meter and when they have been verified separately (for example: electronic printing device). The measurement transducer may

also be tested alone provided that the computing and indicating device has been subject to a separate pattern approval. If this measurement transducer is intended to be connected to a calculator fitted with a correction device, the correction algorithm as described by the manufacturer must be applied to the output signal of the transducer to determine its errors.

6.1.5.2 Accuracy tests

6.1.5.2.1 The errors of the meter shall be determined at a minimum of six flowrates which are distributed over the measuring range at regular intervals. At each flowrate the errors shall be determined at least three times, independently. Each error shall not be greater than the maximum permissible error (in absolute value). In addition, for quantities equal to or greater than five times the minimum measured quantity, the repeatability requirement in 3.1.2.2 applies.

6.1.5.2.2 Tests should be carried out at the limits of the field of operation, i.e. at the limits of pressure, temperature and viscosity. However, pressure tests are not necessary when the technology of the meter is such that it is possible to calculate the influence of pressure and to show that it is negligible (for example: meter with pressure-balanced measuring chambers).

Note: It is often unnecessary to carry out tests with liquids having a temperature which differs from the ambient temperature when the meter is intended to measure liquids having a temperature between $-10\text{ }^{\circ}\text{C}$ and $+50\text{ }^{\circ}\text{C}$.

6.1.5.2.3 The following tests shall also be carried out:

- accuracy test at minimum measured quantity,
- determination of the periodic variation, if appropriate,
- tests with flow disturbances, if appropriate.

For tests with flow disturbances, the applicable maximum permissible errors are those fixed in 2.5 for the measuring system and not those fixed in 3.1.2 for the meter.

6.1.5.2.4 When preliminary verification of the meter is planned to be carried out with a liquid which differs from the liquid the meter is intended to measure, comparative tests with these two liquids shall also be carried out to determine the maximum permissible errors on preliminary verification. It may be necessary to have several specimen of the pattern available.

Example:

It is necessary to make a distinction between a pattern of a meter intended to measure several products (in the same measuring system) and a pattern of a meter of which different copies may be used for measuring different products (in different measuring systems), each copy being intended to measure a given product only.

For example, meter A may be intended to measure butane and propane alternatively, whereas meter B is intended to measure either butane or propane. Both meters will be subject to accuracy tests with butane and with propane at the time of pattern approval. For meter A, the error curves for propane and for butane shall both be within the maximum permissible errors as specified in 3.1.2.

For meter B, the error curves for butane on the one hand, and for propane on the other hand, shall satisfy the maximum permissible errors; unlike meter A, however, these error curves may be determined using different copies of the meter, or alternatively on the same copy whose adjustment (or correction parameters) has been modified between the test with butane and the test with propane.

Copies of meter A will bear the mention of butane and propane on their data plate and they may also be used to measure mixtures of butane and propane in any proportion.

Copies of meter B will bear either the mention “butane” or the mention “propane” and shall be used for measuring the corresponding product exclusively.

The preliminary verification of pattern A copies may be carried out with either butane or propane, indifferently (with, if appropriate, a reduction of the maximum permissible errors range).

In general, the preliminary verification of pattern B copies will be carried out with the liquid intended to be measured; however, it may be carried out with the other liquid provided that the maximum permissible errors have been shifted. The value of shifting shall be determined at the time of pattern evaluation by evaluating the deviation between the error curves determined with butane and with propane, on the same meter, without modification of the adjustment. These deviations shall be reproducible, from one copy of the meter to another. To check this, it is necessary to carry out accuracy tests on several instruments.

6.1.5.3 Endurance tests

Endurance tests should be carried out at the maximum flowrate of the meter using the liquid the meter is intended to measure or a liquid with similar characteristics. When the meter is intended to measure different liquids, the test should be carried out with the liquid that provides the most severe conditions.

An accuracy test shall precede the endurance tests.

In principle the duration of the endurance test shall be 100 hours in one or several periods. In specific cases (e.g. new technologies, new alloys, new liquids) the duration may be increased up to 200 hours.

The test shall be carried out at a flowrate between $0.8 \times Q_{\max}$ and Q_{\max} .

As far as possible, the meter is subjected to the endurance test on a test bench. However, it is accepted that the meter be temporarily mounted in a measuring system in normal operation, in which case it is necessary that the nominal operating flowrate of the measuring system is more than $0.8 \times Q_{\max}$.

After the endurance test, the meter is again subject to a new accuracy test. The deviations between the errors determined before and after the endurance test shall remain within the limits specified in 3.1.2.3 without any changes of the adjustment or corrections.

6.1.6 Pattern approval of a gas elimination device

As a rule, tests shall be carried out to prove that the air or gas eliminating devices satisfy the requirements in 2.10.8 or 2.10.9.

It is however acceptable that tests are not carried out at flowrates greater than 100 m³/h and that the air separating devices are approved by analogy with devices of the same design, having smaller dimensions (see B.1.1.5).

Annex B describes tests which should be carried out on these devices. These tests are given as examples only.

6.1.7 Pattern approval of an electronic calculator

When an electronic calculator is submitted to separate pattern approval, pattern approval tests are conducted on the calculator alone, simulating different inputs with appropriate standards.

6.1.7.1 Accuracy tests include an accuracy test on the indications of measurement results (volume at metering conditions or price to pay). For this purpose, the error obtained on the indication of the result is calculated considering the true value is the one calculated taking into account the value of the simulated quantities applied to inputs of the calculator and using standard methods for calculation. The maximum permissible errors are those fixed in 2.8.

6.1.7.2 When the calculator carries out calculations for a conversion device, tests specified in 6.1.7.1 are performed for the calculation of volume at base conditions or mass.

Accuracy tests also include an accuracy test on the measurement of each characteristic quantity of the liquid. For this purpose, the error obtained on the indication of each of these characteristic quantities (these indications are mandatory considering 3.7.7) is calculated by considering the true value as that provided by the standard connected to the inputs of the calculator and which simulates the corresponding associated measuring instrument. For each of these quantities, the maximum permissible errors fixed in 2.7.3 shall be applied.

It is then necessary to perform a test to check the presence and operation of checking facilities relevant to associated measuring instruments mentioned in 4.3.6.

6.1.7.3 Examinations and tests described in 6.1.11 for electronic instruments shall be performed.

6.1.8 Pattern approval of a conversion device

6.1.8.1 General case

It is necessary to verify whether the conversion device connected to all its associated measuring instruments complies with provisions in 2.7.1. For that purpose, the volume at metering conditions which is converted is supposed to be without any error.

It may also be verified that the provisions in 2.7.4 (and 2.7.5 if applicable) are fulfilled.

In the case of an electronic conversion device, the tests and examination described in 6.1.11 shall be performed.

6.1.8.2 Electronic conversion device

Instead of the procedure in 6.1.8.1, it is also possible

- to verify separately the accuracy of associated measuring instruments (see 2.7.2),
- to verify that the provisions in 6.1.7.2 are fulfilled, and
- to perform examinations and tests described in 6.1.11.

6.1.9 Pattern approval of an ancillary device

6.1.9.1 When an ancillary device that provides primary indications is intended to be approved separately, its indications shall be compared with those provided by an indicating device that has already been approved and which has the same scale interval, or a smaller one.

The results shall satisfy the provisions in 2.9.5.

As far as possible, the necessary conditions for compatibility with other devices of a measuring system are stated in the pattern approval certificate.

6.1.9.2 Electronic devices may be approved separately when they are used for the transmission of primary indications or other information necessary for their determination, e.g. a device which concentrates information from two or more calculators and transmits it to a single printing device.

When at least one of the signals of this information is analogue, the device shall be tested in association with another device whose maximum permissible errors are provided by this Recommendation.

When all the signals of this information are digital, the above provision may be applied; however, when the inputs and outputs of the device are available, the device can be tested separately, in which case it shall introduce no error; only errors due to the testing method may be found out.

In both cases and as far as possible, the necessary conditions for compatibility with other devices of a measuring system are stated in the pattern approval certificate.

6.1.10 Pattern approval of a measuring system

The pattern approval of a measuring system consists of verifying that the constituent elements of the system, which have not been subject to separate pattern approvals, satisfy the applicable requirements, and that these constituent elements are compatible with one another.

Tests for carrying out the pattern approval of a measuring system shall therefore be determined on the basis of the pattern approvals already granted for the constituent elements of the system.

When none of the constituent elements has been subject to separate pattern approval, all the tests provided for in 6.1.5, 6.1.6 and 6.1.7 (in particular) shall be performed on the complete measuring system. On the contrary, when the various constituent elements are all approved separately, it is possible to replace pattern approval based on tests by pattern approval of drawings.

It is also appropriate to reduce the pattern evaluation program when the measuring system includes constituent elements identical to those which equip another measuring system that has already been approved, and when the operating conditions of these elements are identical. For example, it is not necessary to perform the expansion test of a hose in a fuel dispenser when the hose in this measuring system is identical to the hose equipping another measuring system already approved with the same minimum measured quantity.

Note: It is advisable that constituent elements be subject to separate pattern approval when they are intended to equip several patterns of measuring systems. This is particularly advisable when the various measuring systems have different manufacturers and when the bodies in charge of pattern approval are different.

6.1.11 Pattern approval of an electronic device

In addition to the examinations or tests described in the preceding paragraphs, an electronic measuring system or an electronic constituent element of this system shall be subject to the following tests and examinations.

6.1.11.1 Design inspection

This examination of documents aims at verifying that the design of electronic devices and their checking facilities comply with the provisions of this Recommendation, clause 4 in particular.

It includes:

- a) an examination of the mode of construction and of the electronic sub-systems and components used, to verify their appropriateness for their intended use,

- b) consideration of faults likely to occur, to verify that in all considered cases these devices comply with the provisions of 4.3,
- c) verification of the presence and effectiveness of the test device(s) for the checking facilities.

6.1.11.2 Performance tests

These tests aim at verifying that the measuring system complies with the provisions of 4.1.1 with regard to influence quantities. These tests are specified in Annex A.

- a) Performance under the effect of influence factors:

When subjected to the effect of influence factors as provided for in Annex A, the equipment shall continue to operate correctly and the errors shall not exceed the applicable maximum permissible errors.

- b) Performance under the effect of disturbances:

When subjected to external disturbances as provided for in Annex A, the equipment shall either continue to operate correctly or detect and indicate the presence of any significant faults. Significant faults shall not occur on non-interruptible measuring systems.

6.1.11.3 Equipment under test (EUT)

Tests are carried out on the complete measuring system where size and configuration permit, except where otherwise specified in Annex A.

Where tests are not carried out on a complete system, they shall be carried out on a sub-system comprising at least the following devices:

- measuring transducer,
- calculator,
- indicating device,
- power supply device,
- correction device, if appropriate.

This sub-system shall be included in a simulation set-up representative of the normal operation of the measuring system. For example, the movement of the liquid may be simulated by an appropriate device.

The calculator shall be in its final housing.

In all cases, peripheral equipment may be tested separately.

6.2 Initial verification

6.2.1 General

Initial verification of a measuring system is carried out in a single stage when the system can be transported without dismantling and when it is verified under the intended conditions of use; in all other cases, it is carried out in two stages.

The first stage concerns at least the measurement transducer, alone or fitted with associated ancillary devices, or possibly included in a sub-system. Tests of the first stage may be carried out on a test bench, possibly in the factory of the manufacturer, or on the installed measuring system. At this stage, the metrological examinations may be carried out with different liquids than those which the system is intended to measure.

The first stage also concerns the calculator and the density sensor. If necessary, the measurement transducer and the calculator can be verified separately.

The second stage concerns the measuring system in actual working condition. It is carried out at the place of installation under operating conditions and with the intended liquid of use. However, the second stage may be carried out in a place chosen by the verification body when the measuring system can be transported without dismantling and when the tests can be performed under the operating conditions intended for the measuring system.

Initial verification of electronic systems shall include a procedure for verifying the presence and correct operation of checking facilities by the use of test devices as specified in 4.3.

6.2.2 Tests

6.2.2.1 When initial verification takes place in two stages, the first stage shall include:

- an examination for conformity of the meter, including the associated ancillary devices (conformity with the respective patterns),
- a metrological examination of the meter, including the associated ancillary devices.

The second stage shall include:

- an examination for conformity of the measuring system, including the meter and the ancillary and additional devices,
- a metrological examination of the measuring system; if possible, this examination is carried out within the limits of operating conditions for the system,
- an operational test of the gas elimination device, where appropriate, with no need to verify that the maximum errors applicable to this device and specified in 2.10 are met,
- an inspection of the adjustment of the prescribed pressure maintaining devices where appropriate,
- when necessary, a test of the variations of the internal volume of the hoses in full hose measuring systems, e.g. in the case of a hose reel,
- an operational test of the control valve preventing the emptying of the hose during non-operating periods, for full hose measuring systems,
- a determination of the residual quantities in empty hose measuring systems.

6.2.2.2 When initial verification takes place in one stage, all tests in 6.2.2.1 shall be performed.

6.3 Subsequent verification

6.3.1 Subsequent verification of a measuring system may be identical to initial verification.

6.3.2 The preliminary examination of the meter should only be repeated if the protective marks on the measuring element of the meter have been damaged. This examination may be replaced by a test of the measuring system if the conditions for the preliminary examination are met and if the measuring system can undergo testing with a volume of liquid corresponding to the minimum measured quantity. For the determination of the error curve, at least 60 % of the maximum flowrate should be reached.

6.3.3 The ancillary devices shall be considered as having been subjected to the preliminary examination if the protective marks are not damaged. It is sufficient to carry out a reduced number of measurements during the simplified examination of the ancillary devices.

ANNEX A

PERFORMANCE TESTS FOR
ELECTRONIC MEASURING SYSTEMS
(Mandatory)

A.1 General

This Annex defines the program of performance tests intended to verify that electronic measuring systems may perform and function as intended in a specified environment and under specified conditions. Each test indicates, where appropriate, the reference conditions for determining the intrinsic error.

These tests supplement any other prescribed test.

When the effect of one influence quantity is being evaluated, all other influence quantities are to be held relatively constant, at values close to reference conditions.

A.2 Severity levels (see OIML D 11)

For each performance test, typical test conditions are indicated: they correspond to the climatic and mechanical environment conditions to which measuring systems are usually exposed.

Measuring systems are divided into three classes according to climatic and mechanical environmental conditions:

- class B for fixed instruments installed in a building,
- class C for fixed instruments installed outdoors,
- class I for mobile instruments, in particular measuring systems on trucks.

However, the applicant for pattern approval may indicate specific environmental conditions in the documentation supplied to the metrology service, based on the intended use of the instrument. In this case, the metrology service carries out performance tests at severity levels corresponding to these environmental conditions. If pattern approval is granted, the data plate shall indicate the corresponding limits of use. Manufacturers shall inform potential users of the conditions of use for which the instrument is approved. The metrology service shall verify that the conditions of use are met.

A.3 Reference conditions

Ambient temperature:	20 °C ± 5 °C
Relative humidity:	60 % ± 15 %
Atmospheric pressure:	86 kPa to 106 kPa
Power voltage:	Nominal voltage (V_{nom})
Power frequency:	Nominal frequency (F_{nom})

During each test, the temperature and relative humidity shall not vary by more than 5 °C or 10 % respectively within the reference range.

A.4. Performance tests

The following tests can be carried out in any order.

Test	Nature of the influence quantity	Severity level for the class (by ref. to OIML D 11)		
		B	C	I
A.4.1 Dry heat	Influence factor	2	3	3
A.4.2 Cold	Influence factor	2	3	3
A.4.3 Damp heat, cyclic	Influence factor	1	2	2
A.4.4 Vibration (sinusoidal)	Influence factor	–	–	3
A.4.5 Power voltage variation	Influence factor	1	1	1
A.4.6 Short time power reductions	Disturbance	1a & 1b	1a & 1b	1a & 1b
A.4.7 Bursts	Disturbance	2	2	2
A.4.8 Electrostatic discharge	Disturbance	1	1	1
A.4.9 Electromagnetic susceptibility	Disturbance	2, 5, 7	2, 5, 7	2, 5, 7
A.4.10 Disturbances on d.c. voltage powered equipment				

The above tests involve the electronic part of the measuring system or its devices.

The following rules shall be taken into consideration for these tests:

1) Tests volumes

Some influence quantities should have a constant effect on measurement results and not a proportional effect related to the measured volume. The value of the significant fault is related to the measured volume; therefore, in order to be able to compare results obtained in different laboratories, it is necessary to perform a test on a volume corresponding to that delivered in one minute at the maximum flowrate, but not less than the minimum measured quantity. Some tests, however, may require more than one minute, in which case they shall be carried out in the shortest possible time.

2) Influence of the liquid temperature

Temperature tests concern the ambient temperature and not the temperature of the liquid used. It is therefore advisable to use a simulation test method so that the temperature of the liquid does not influence the test results.

A.4.1 Dry heat

Test method: Dry heat (non condensing)

Object of the test: To verify compliance with the provisions in 4.1.1 under conditions of high temperature.

References: ~~IEC Publications 68-2-2, fourth edition, 1974, Basic environmental testing procedures, Part 2: Tests, Test Bd: Dry heat, for heat dissipating equipment under test EUT with gradual change temperature.~~
~~Background information concerning dry heat tests is given in IEC Publication 68-3-1, first edition, 1974 and first supplement 68-3-1A, 1978, Part 3: background information, section one: Cold and dry heat test.~~
~~General background information on basic environmental testing procedures is given in IEC Publication 68-1, fourth edition, 1978.~~

Test procedure in brief (*): The test consists of exposure of the EUT to a temperature of 55 °C (classes C or I) or 40 °C (class B) under “free air” conditions for a 2-hour period after the EUT has reached temperature stability. The EUT shall be tested at at least one flow rate (or simulated flowrate):

- at the reference temperature of 20 °C following conditioning,
- at the temperature of 55 °C or 40 °C, 2 hours after temperature stabilization,
- after recovery of the EUT at the reference temperature of 20 °C.

Test severities:

- 1) Temperature: severity level 2: 40 °C
severity level 3: 55 °C
- 2) Duration: 2 hours

Number of test cycles: One cycle

Maximum allowable variations: All functions shall operate as designed.
All errors shall be within the maximum permissible errors.

A.4.2 Cold

Test method: Cold

Object of the test: To verify compliance with the provisions in 4.1.1 under conditions of low temperature.

References: ~~IEC Publication 68-2-1, fourth edition, 1974, Basic environmental testing procedures, Part 2: Tests, test Ad: Cold, for heat dissipating EUT with gradual change of temperature.~~
~~Background information concerning cold tests is given in IEC Publication 68-3-1, first edition 1974 and first supplement 68-3-1A, 1978 Part 3: Background informa~~

(*) This test procedure has been given in condensed form, for information only, and is adapted from the referenced IEC-publication. Before conducting the test, the applicable publication should be consulted. This comment also applies to the test procedures hereafter.

Standard stabilizing period before and recovery after the cyclic exposure are indicated in IEC Publication 68-2-30. The power supply is not on when the influence factor is applied.

Test severities: 1) Upper temperature: severity level 1: 40 °C
severity level 2: 55 °C
2) Humidity: > 93 %
3) Duration: 24 hours

Number of test cycles: Two cycles

Maximum allowable variations: After the application of the influence factor and recovery:

- all functions shall operate as designed and
- all errors shall be within the maximum permissible errors.

A.4.4 Vibration

Test method: Sinusoidal vibration

Object of the test: To verify compliance with the provisions in 4.1.1 under conditions of sinusoidal vibration.
This test should normally apply to mobile measuring systems only.

References: ~~IEC Publication 68-2-6, fifth edition, 1982, Basic environmental testing procedures, Part 2: Test, test Fe: Vibration (sinusoidal)~~

Test procedure in brief: The EUT shall be tested by sweeping the frequency in the specified frequency range, at 1 octave/minute, at the specified acceleration level with a specified number of sweep cycles per axis. The EUT shall be tested in its three, mutually perpendicular main axes, mounted on a rigid fixture by its normal mounting means. It shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use.
The instrument is non-operational when the influence factor is applied.

Test severities: 1) Frequency range: 10–150 Hz
2) Max. acceleration level: 20 m.s⁻²

Number of test cycles: 20 sweep cycles per axis

Maximum allowable variations: After the application of the influence factor and recovery:

- all functions shall operate as designed and
- all errors shall be within the maximum permissible errors.

A.4.5 Power voltage variation

Test method:	Variation in a.c. mains power supply (single phase)
Object of the test:	To verify compliance with the provisions in 4.1.1 under conditions of varying a.c. mains power supply.
References:	No reference to an international standard can be given at the present time.
Test procedure in brief:	The test consists of exposure of the EUT to power voltage variations, while the EUT is operating under normal atmospheric conditions.
Test severities:	Mains voltage: upper limit: $V_{\text{nom}} + 10 \%$ lower limit: $V_{\text{nom}} - 15 \%$
Number of test cycles:	One cycle
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors.

A.4.6 Short time power reduction

Test method:	Short time interruptions and reductions in mains voltage
Object of the test:	To verify compliance with the provisions in 4.1.1 under conditions of short time mains voltage interruptions and reductions.
References:	No reference to international standard can be given at the present time.
Test procedure in brief:	The test consists of subjecting the EUT to voltage interruptions from nominal voltage to zero voltage for a duration equal to half a cycle of line frequency, and reductions from nominal voltage to 50 % of nominal for a duration equal to one cycle of line frequency. The mains voltage interruptions and reductions shall be repeated ten times with a time interval of at least ten seconds.
Test severities:	100 % voltage interruption for a period equal to half a cycle. 50 % voltage reduction for a period equal to one cycle.
Number of test cycles:	At least ten interruptions and ten reductions, each with a minimum of ten seconds between tests. The interruptions and reductions are repeated throughout the time necessary to perform the whole test; for this reason, more than ten interruptions and reduction may be necessary.

- Maximum allowable variations: a) for interruptible measuring systems, either the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12 or the measuring system shall detect and act upon a significant fault, in compliance with 4.3.1.
- b) for non-interruptible measuring systems, the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12.

A.4.7 Bursts

- Test method: Electrical bursts
- Object of the test: To verify compliance with the provisions in 4.1.1 under conditions where electrical bursts are superimposed on the mains voltage.
- References: ~~IEC Publication 801-4 (1988)~~
- Test procedure in brief: The test consists of subjecting the EUT to bursts of double exponential waveform transient voltages. Each spike shall have a rise time of 5 ns and a half amplitude duration of 50 ns. The burst length shall be 15 ms, the burst period (repetition time interval) shall be 300 ms. All bursts shall be applied during the same measurement or simulated measurement in symmetrical mode and asymmetrical mode.
- Test severities: Amplitude (peak value) 1 000 V
- Number of test cycles: At least ten positive and ten negative randomly phased bursts shall be applied at 1 000 V.
The bursts are applied during all the time necessary to perform the test; to that purpose more bursts than indicated above may be necessary.

- Maximum allowable variations: a) for interruptible measuring systems, either the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12 or the measuring system shall detect and act upon a significant fault, in compliance with 4.3.1,
- b) for non-interruptible measuring systems, the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12.

A.4.8 Electrostatic discharge

- Test method: Electrostatic discharge (ESD)
- Object of the test: To verify compliance with the provisions in 4.1.1 under conditions of direct and indirect electrostatic discharges.

References:	IEC Publication 801-2 (1991)
Test procedure in brief:	<p>A capacitor of 150 pF is charged by a suitable DC voltage source. The capacitor is then discharged through the EUT by connecting one terminal to ground (chassis) and the other via 330 ohms to surfaces which are normally accessible to the operator.</p> <p>The test includes the paint penetration method, if appropriate. For direct discharges the air discharge shall be used where the contact discharge method cannot be applied.</p>
Test severities:	<p>8 kV for air discharges 6 kV for contact discharges</p>
Number of test cycles:	At each test point, at least ten direct discharges shall be applied at intervals of at least ten seconds between discharges, during the same measurement or simulated measurement. As for indirect discharges, a total of ten discharges shall be applied on the horizontal coupling plane, and a total of ten discharges for the various positions of the vertical coupling plane.
Maximum allowable variations:	<p>a) for interruptible measuring systems, either the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12 or the measuring system shall detect and act upon a significant fault, in compliance with 4.3.1,</p> <p>b) for non-interruptible measuring systems, the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12.</p>

A.4.9 Electromagnetic susceptibility

Test method:	Electromagnetic fields (radiated)
Object of the test:	To verify compliance with the provisions in 4.1.1 under conditions of electromagnetic fields.
References:	IEC Publication 801-3 (under revision in 1995)
Test procedure in brief:	<p>The EUT shall be exposed to electromagnetic field strength as specified by the severity level.</p> <p>The field strength can be generated in various ways:</p> <ul style="list-style-type: none"> • the strip line is used at low frequencies below 30 MHz (or in some cases 150 MHz) for small EUT's; • the long wire is used at low frequencies (below 30 MHz) for larger EUT's; • dipole antennas or antennas with circular polarization placed 1 m from the EUT are used at high frequencies. <p>The specified field strength shall be established prior to the actual testing (without EUT in the field).</p>

~~The field shall be generated in two orthogonal polarizations and the frequency range shall be scanned slowly. If antennas with circular polarization i.e. log spiral or helical antennas are used to generate the electromagnetic field, a change in the position of the antennas is not required. When the test is carried out in a shielded enclosure to comply with international laws prohibiting interference to radio communications, care should be taken to handle reflections from the walls. Anechoic shielding may be necessary.~~

Test severities:

Frequency range	26-500 MHz	500-1000 MHz
Field strength	3 V/m	1 V/m
Modulation	80% AM, 1 kHz sine wave	

- Maximum allowable variations: a) ~~for interruptible measuring systems, either the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12 or the measuring system shall detect and act upon a significant fault, in compliance with 4.3.1,~~
- b) ~~for non-interruptible measuring systems, the difference between the volume indication during the test and the indication under reference conditions shall not exceed the values given in T.3.12.~~

A.4.10 Perturbations on dc voltage powered instruments

Electronic measuring systems supplied with dc voltage shall fulfill the tests in A.4.1 to A.4.9, with the exception of A.4.5, A.4.6 and A.4.7 which are to be replaced by the following provisions.

General provision

For under-voltages or over-voltages all errors shall be within maximum permissible errors when the instrument is still operating.

The under-voltage or over-voltage is applied for a complete measurement or part of a measurement.

Provision applicable to instruments fed by the battery of a vehicle

Tests pulses 1, 2 and 3 of the relevant part of ISO 7637 *Electrical disturbance by conduction and coupling, Part 1: Vehicles with nominal 12 V supply voltage, and Part 2: Commercial vehicles with nominal 24 V supply voltage*, are applied at the various severity levels specified in this Standard.

Pulses are repeated for as long as necessary to complete the test.

The pattern approval certificate shall indicate, for each type of pulse, the maximum severity level met by the instrument.

ANNEX B
TESTING OF GAS ELIMINATION DEVICES
(Informative)

This Annex, developed by a joint ISO-OIML working group, concerns sub-clause 6.1.6. The following tests are recommended.

B.1 Testing of a gas elimination device as a unit separate from the measuring system for which it is intended

B.1.1 General provisions

In order to examine whether the pattern of a gas elimination device complies with the requirements in 2.10, a specimen of the pattern must be installed on a suitable test bench equipped with a meter and a conventional proving tank.

Note: In tests on gas elimination devices, the proving tank may be replaced by any appropriate standard.

The efficiency of the gas elimination device is determined with reference to the meter error at the same flowrate.

The test bench must, as far as possible, comply with the following provisions:

- the capacity of the proving tank should be at least equal to the greater of the following two values: volume delivered in one minute at maximum flowrate, or 1 000 times the scale interval of the meter on the test bench;
- it is recommended that an adjustable non-return valve be installed downstream of the meter in order to prevent back flow of the liquid which has been measured and to obtain the minimum back pressure required for the proper operation of the gas elimination device;
- there should be no reverse gradient in the pipework downstream of the meter so that gas bubbles are allowed to escape in the normal way in order to keep this pipework filled to the same level at the beginning and end of the test;
- the liquid used for the tests should either be the same as that for which the device is intended or should be of a viscosity which is at least equal to that of the liquid for which it is intended.

Tests on gas elimination devices should be carried out for flowrates up to a maximum of 100 m³/h. For higher flowrates, characteristics may be determined by analogy with equipment of the same design and smaller dimensions. "By analogy" means that parameters like Reynolds number, Froude number, etc. are to be taken into account for the gas elimination device.

B.1.2 Tests on gas separators

The volume of air or gas continuously entering may be measured by a gas meter and isothermally converted to atmospheric pressure on the basis of the indication of a pressure gauge fitted upstream of the gas meter.

A pressure gauge positioned upstream of the meter for liquid makes it possible to determine the lowest pressure at which the gas separator still meets the efficiency requirements.

Before starting a test, the whole apparatus is made to operate at the desired liquid and gas flowrates so that all parts of the apparatus (except the proving tank) fill up under set conditions as regards the entry of air or gas.

The air may be introduced either by injection downstream of the pump or by suction upstream of it (see Figures 1, 2 and 3, which are given as examples).

In the former case, which makes it possible to operate without changing the performance of the pump due to the entry of air, the liquid and gas flows are adjusted by means of control valves. The air or gas is introduced through a tube positioned in the center of the pipework for the liquid, for example at an elbow.

In the latter case, which reproduces the conditions encountered in reality (pressure reduction by suction), the pump must be set to the maximum flowrate of the separator. If the pump has too great a flowrate, it must be possible to regulate it with a speed reducer. The pump should preferably be of the volumetric type but it may also be of the centrifugal type if the supply tank feeds the pump by gravity. The pressure reduction must then be regulated by a valve positioned upstream of the pump, and the air inlet must be equipped with a non-return valve which prevents any leakage at the moment of switching off.

B.1.3 Test on gas extractors

An example of test bench is shown in Figure 4.

It includes a container for creating a pocket of air to be removed with a volume equal to the minimum measured quantity of the gas extractor (the minimum measured quantity of the system being not yet specified). When the test is carried out with a proving tank having such a great capacity that the maximum permissible error cannot be evaluated correctly on the basis of a single operation of the gas extractor, the number of operations during the same test shall be multiplied by 2, 3 or 4, to obtain the required accuracy.

B.1.4 Tests on special gas extractors

Special gas extractors, mainly used for measuring systems on road tankers, are principally intended to prevent measurement errors which may arise from the complete emptying of one compartment. They must also separate and continuously remove introduced air, although to a lesser degree than a gas separator.

In the case of separate approval, they should be tested on a test bench which corresponds in principle to Figure 5.

This test bench is similar to that in Figure 1 but it differs in order to reproduce the actual conditions of delivery from road tankers to underground tanks, as is the case when service stations are supplied with petrol, and domestic fuel oil deliveries are made. Thus, the supply tank is located above the special gas extractor and the meter, i.e. at a level corresponding to that of road tanker, and the proving tank is approximately 4 m below the meter.

In order to determine the additional error arising from the complete emptying of a road tanker, which may be caused by the air drawn in at the end of the delivery by the formation of a vortex, the supply tank is filled with a volume of liquid equivalent to that of the proving tank. The liquid is then emptied through the meter into the proving tank without operating the shut-off valve.

For delivery by gravity, pipework is used which bypasses the pump.

Due to the existence of the automatic shut-off valve in the hydraulic circuit connected to the gas extractor, the pocket of air to be evacuated (described in B.1.3) may be created by emptying the pipework between the tank and the gas extractor.

Furthermore, given that a special elimination device should also perform the function of a separator for a small percentage of air introduced continuously (see 2.10.9), it is necessary to carry out this test in a manner comparable to the tests described for separators in B.1.2, with air being either injected into the supply pipework or drawn in upstream of the pump by creating an entry of air and partly closing the valve of the supply tank.

B.2 Tests on gas elimination devices forming part of a measuring system during pattern approval

The tests are carried out with a proving tank of the capacity specified in B.1.1, or any appropriate standard.

B.2.1 Tests on a gas separator

This examination particularly applies to patterns of separators included in measuring systems which can be mass produced and transported without dismantling, such as petrol pumps fed by their own supply pumps.

The essential part of the test bench (Figure 6) is the measuring system itself (in this case, the fuel dispenser).

In accordance with conditions encountered in actual use, the liquid is drawn up from a tank on a lower level than the meter. The air is drawn in by suction through a special inlet equipped with a control valve. The air can be measured by a gas meter. However, it is not necessary to use a gas meter if the separator is capable of separating and eliminating the air introduced in any proportion, as provided in 2.10.8.

The requirements in 2.10.1 and 2.10.8 should be complied with under test conditions such that the maximum flowrate of the measuring system is reached when no air enters.

B.2.2 Tests on a gas extractor and a special gas extractor

The measuring system comprising the gas elimination device must be constructed so that the tests can be carried out as described in B.1.3 or B.1.4.

B.3 Tests on gas elimination devices forming part of a measuring system during verification

The gas elimination devices are tested without it being necessary to verify that the maximum permissible errors for the individual units are complied with.

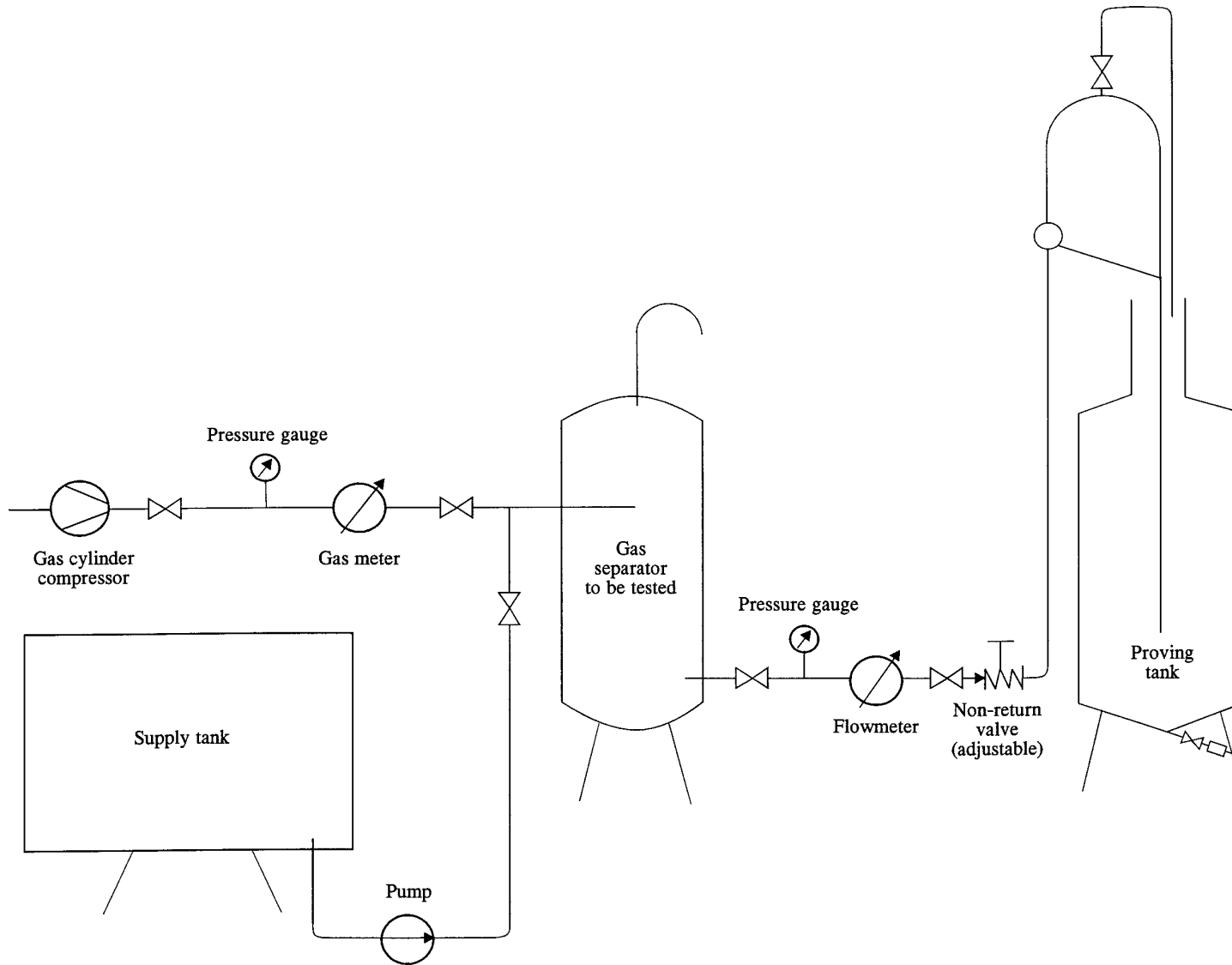


Figure 1 - Test bench for gas separators

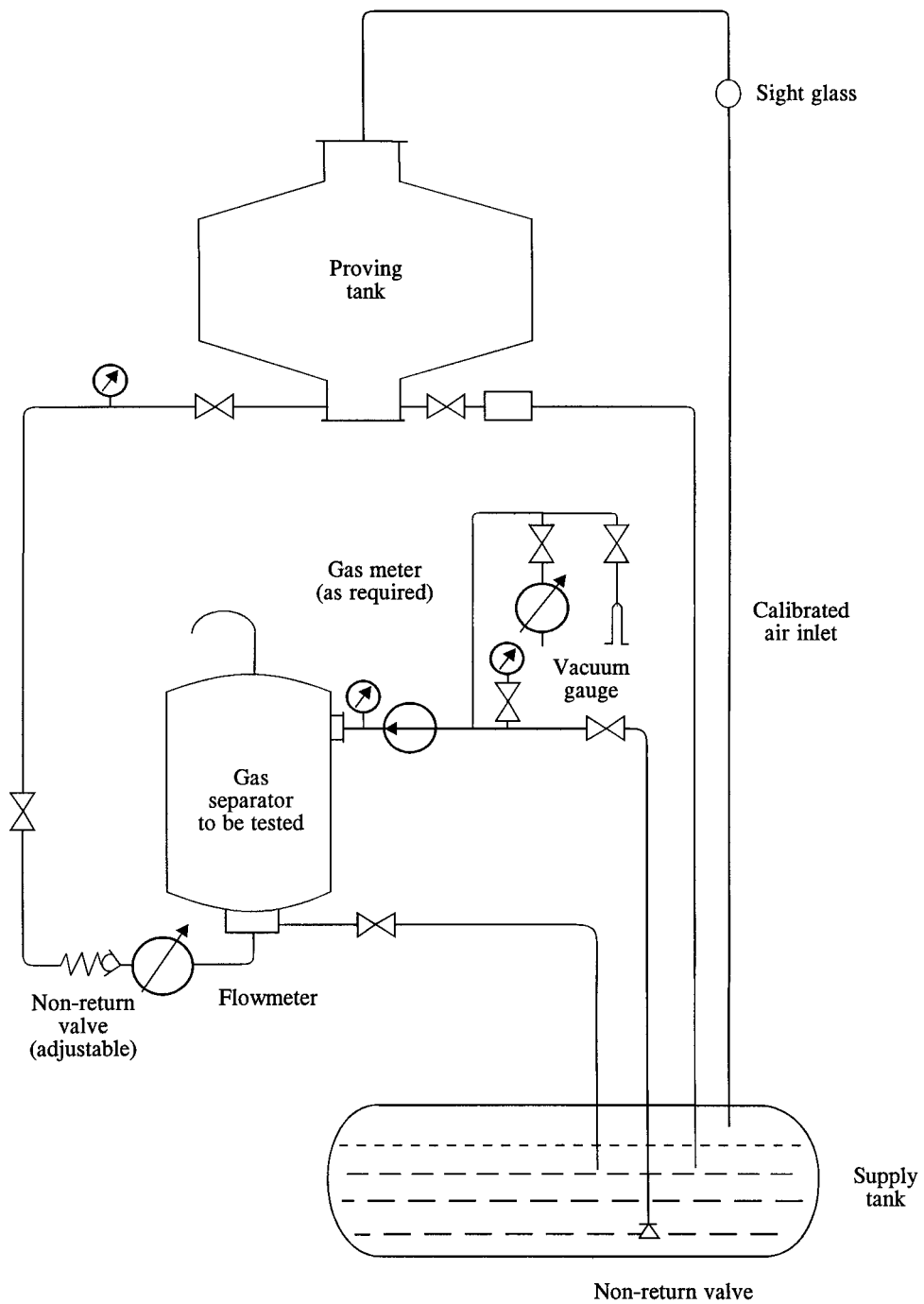


Figure 2 - Test bench for gas separators

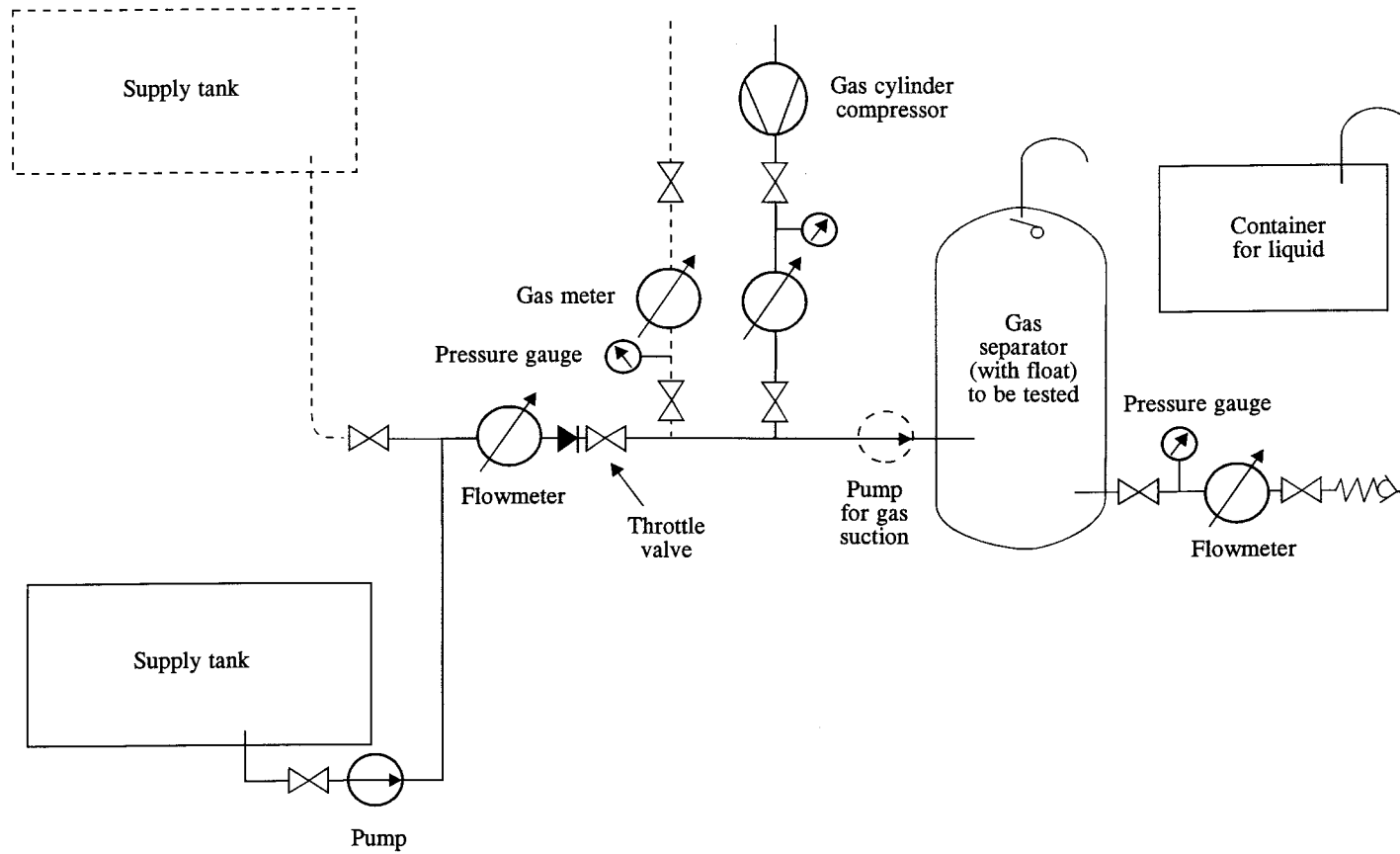


Figure 3 - Test bench for gas separators
—— with gas injection
----- with gas suction

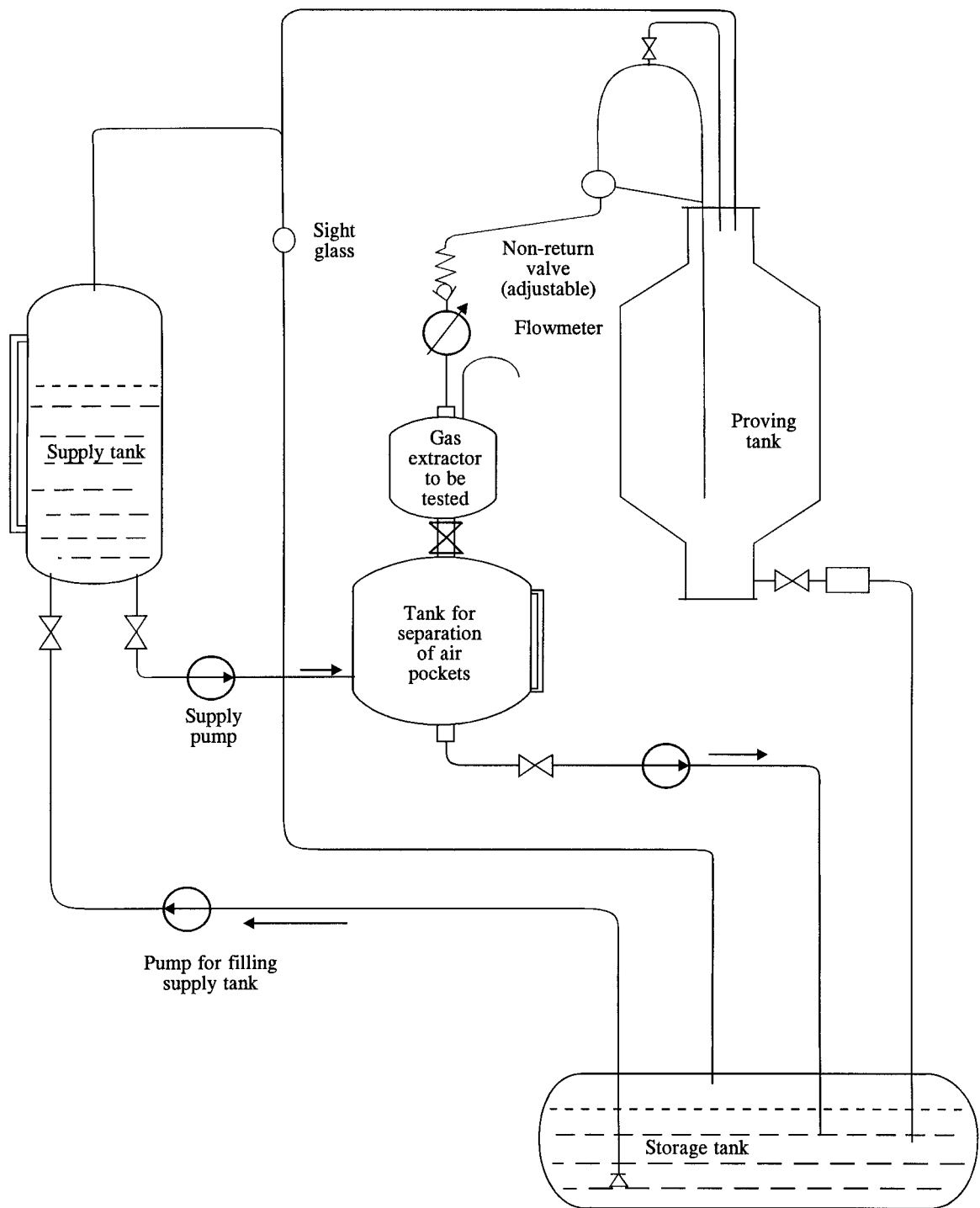


Figure 4 - Test bench for gas extractors

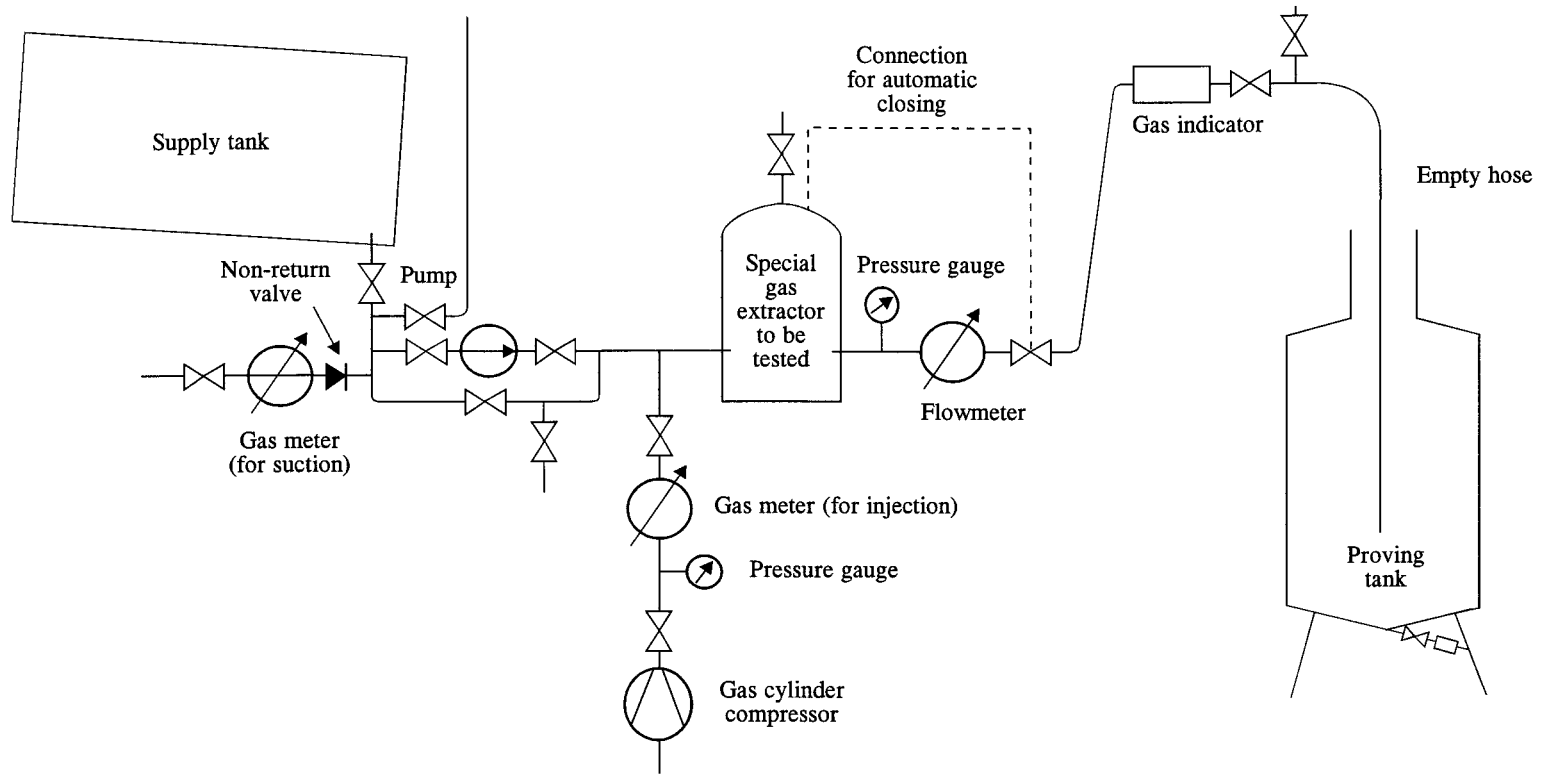


Figure 5 - Test bench for special gas extractors

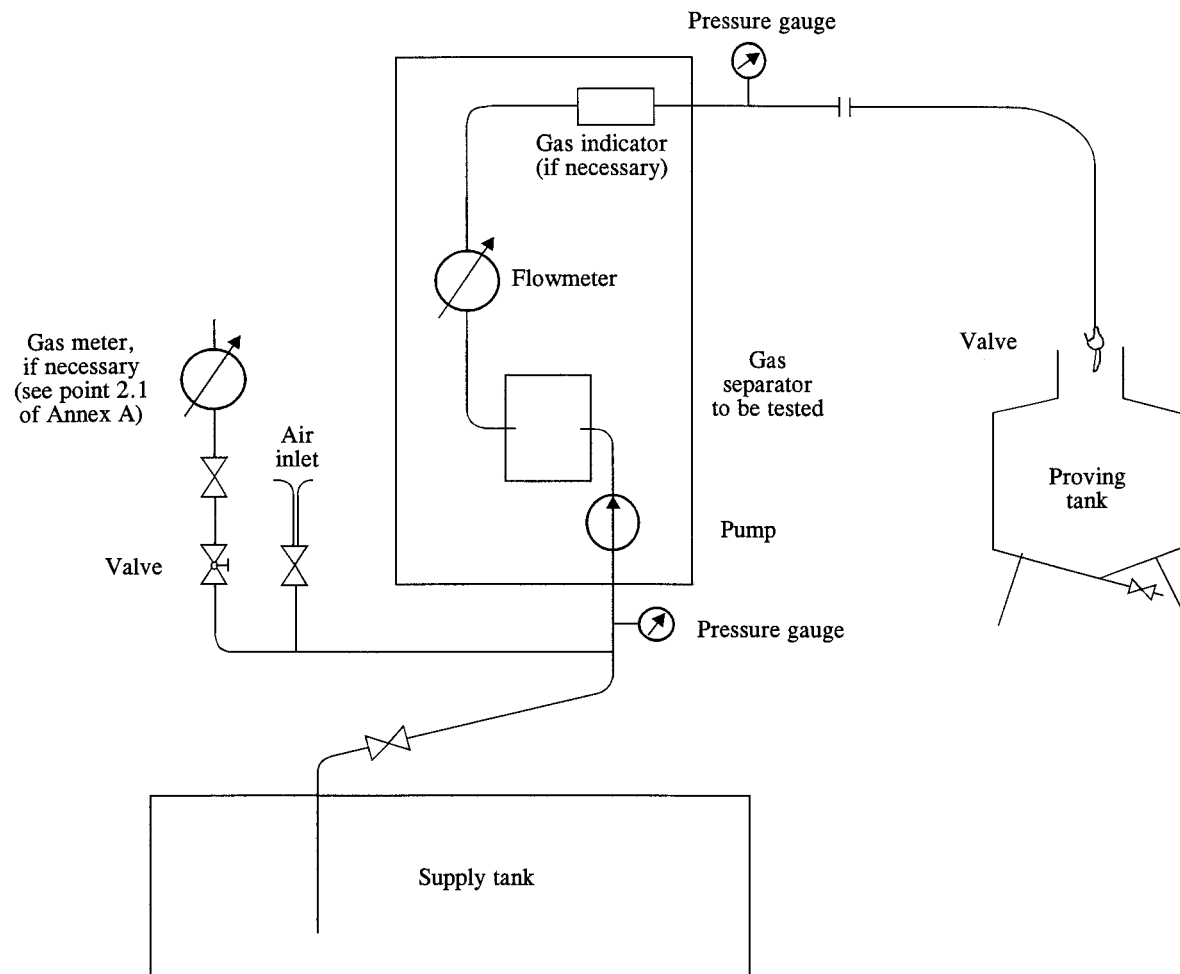


Figure 6 - Testing facility for gas separators in fuel dispensers

ANNEX C

TERMINOLOGY CLASSIFIED BY ALPHABETICAL ORDER AND BY THEME (Informative)

C.1 Alphabetical classification

Absolute error of measurement T.3.2
Aircraft hydrant measuring system T.2.4
Aircraft refuelling tanker measuring system T.2.3
Additional device T.1.6
Adjustment device T.1.9
Ancillary device T.1.5
Associated measuring instruments T.1.10
Attended post-payment (or post-payment) T.2.11
Attended service mode T.2.8
Authorization of a measuring system T.2.13
Automatic checking facility T.5.5
Base conditions T.1.14
Blend dispenser T.2.5
Calculator T.1.3
Checking facility T.5.4
Condenser tank T.1.19
Conversion device T.1.12
Correction device T.1.11
Cyclic volume T.3.15
Direct selling to the public T.2.14
Disturbance T.4.3
Durability T.3.13
Electronic component T.5.3
Electronic device T.5.1
Electronic sub-assembly T.5.2
Endurance test T.4.7
Fault T.3.12
First element of an indicating device T.3.17
Fuel dispenser T.2.1
Gas extractor T.1.17
Gas indicator T.1.20
Gas separator T.1.16
Indicating device T.1.4
Influence factor T.4.2
Influence quantity T.4.1
Initial intrinsic error T.3.10
Intermittent automatic checking facility (type I) T.5.7
Interruptible and non-interruptible measuring system T.3.14
Intrinsic error T.3.9

Maximum permissible error T.3.4
Measurement transducer T.1.2
Measuring system T.1.7
Measuring system on pipeline T.2.2
Meter for volumes of liquids T.1.1
Metering conditions T.1.13
Minimum measured quantity of a measuring system T.3.5
Minimum specified price deviation T.3.7
Minimum specified volume deviation T.3.6
Nonautomatic checking facility (type N) T.5.8
Performance test T.4.6
Periodic variation T.3.16
Permanent automatic checking facility (type P) T.5.6
Power supply device T.5.9
Pre-payment T.2.10
Pre-setting device T.1.8
Primary indication T.3.1
Rated operating conditions T.4.4
Reference conditions T.4.5
Relative error T.3.3
Repeatability error T.3.8
Self-service arrangement T.2.6
Self-service device T.2.7
Sight glass T.1.21
Significant fault T.3.12
Special gas extractor T.1.18
Transfer point T.1.15
Unattended post-payment (or delayed payment) T.2.12
Unattended service mode T.2.9
Uncertainty of the estimation of an error T.4.8

C.2 Classification by theme

Measuring system and additional devices:

Measuring system T.1.7
Additional device T.1.6
Transfer point T.1.15
Gas separator T.1.16
Gas extractor T.1.17
Special gas extractor T.1.18
Condenser tank T.1.19
Gas indicator T.1.20
Sight glass T.1.21

Meter:

Meter for volumes of liquids T.1.1
Measurement transducer T.1.2
Adjustment device T.1.9

Correction device T.1.11
Calculator T.1.3
Indicating device T.1.4
Power supply device T.5.9
Cyclic volume T.3.15
Periodic variation T.3.16
First element of an indicating device T.3.17

Devices:

Ancillary device T.1.5
Conversion device T.1.12
Associated measuring instruments T.1.10
Pre-setting device T.1.8

Electronic equipment:

Electronic device T.5.1
Electronic sub-assembly T.5.2
Electronic component T.5.3

Characteristics of the measuring system:

Minimum measured quantity of a measuring system T.3.5
Interruptible and non-interruptible measuring system T.3.14
Durability T.3.13
Primary indication T.3.1

Types of measuring systems:

Measuring system on pipeline T.2.2
Fuel dispenser T.2.1
Blend dispenser T.2.5
Aircraft hydrant measuring system T.2.4
Aircraft refuelling tanker measuring system T.2.3

Dispensers with self-service devices:

Self-service arrangement T.2.6
Self-service device T.2.7
Attended service mode T.2.8
Unattended service mode T.2.9
Pre-payment T.2.10
Attended post-payment (or post-payment) T.2.11
Unattended post-payment (or delayed payment) T.2.12
Authorization of a measuring system T.2.13
Direct selling to the public T.2.14

Error and minimum deviation:

Absolute error of measurement T.3.2
Relative error T.3.3
Maximum permissible error T.3.4
Minimum specified volume deviation T.3.6
Minimum specified price deviation T.3.7
Repeatability error T.3.8

Intrinsic error, fault:

Intrinsic error T.3.9

Initial intrinsic error T.3.10

Fault T.3.11

Significant fault T.3.12

Influence factor and disturbance:

Influence quantity T.4.1

Influence factor T.4.2

Disturbance T.4.3

Conditions:

Metering conditions T.1.13

Base conditions T.1.14

Rated operating conditions T.4.4

Reference conditions T.4.5

Checking facilities:

Checking facility T.5.4

Automatic checking facility T.5.5

Permanent automatic checking facility (type P) T.5.6

Intermittent automatic checking facility (type I) T.5.7

Nonautomatic checking facility (type N) T.5.8

Tests:

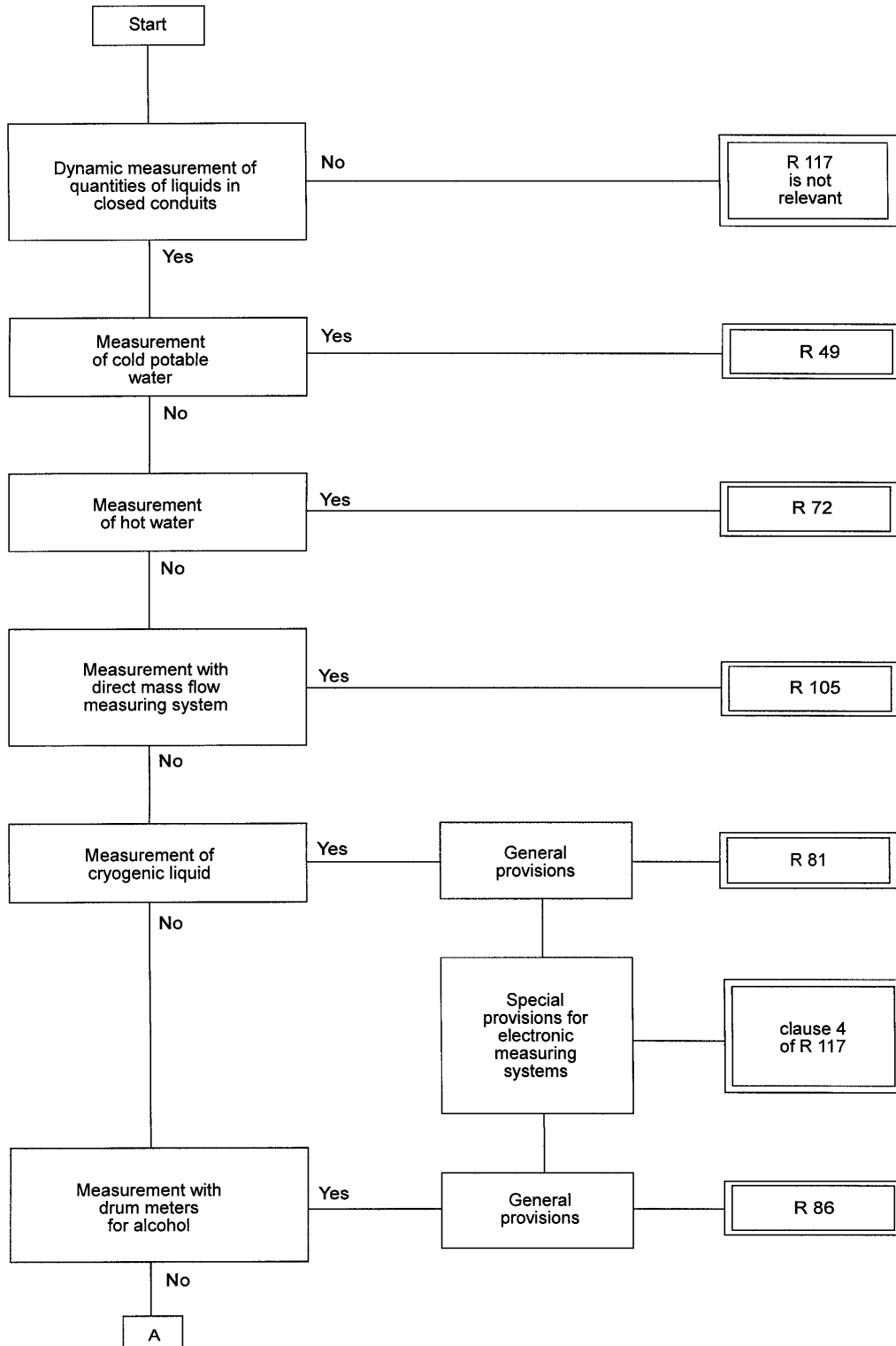
Performance test T.4.6

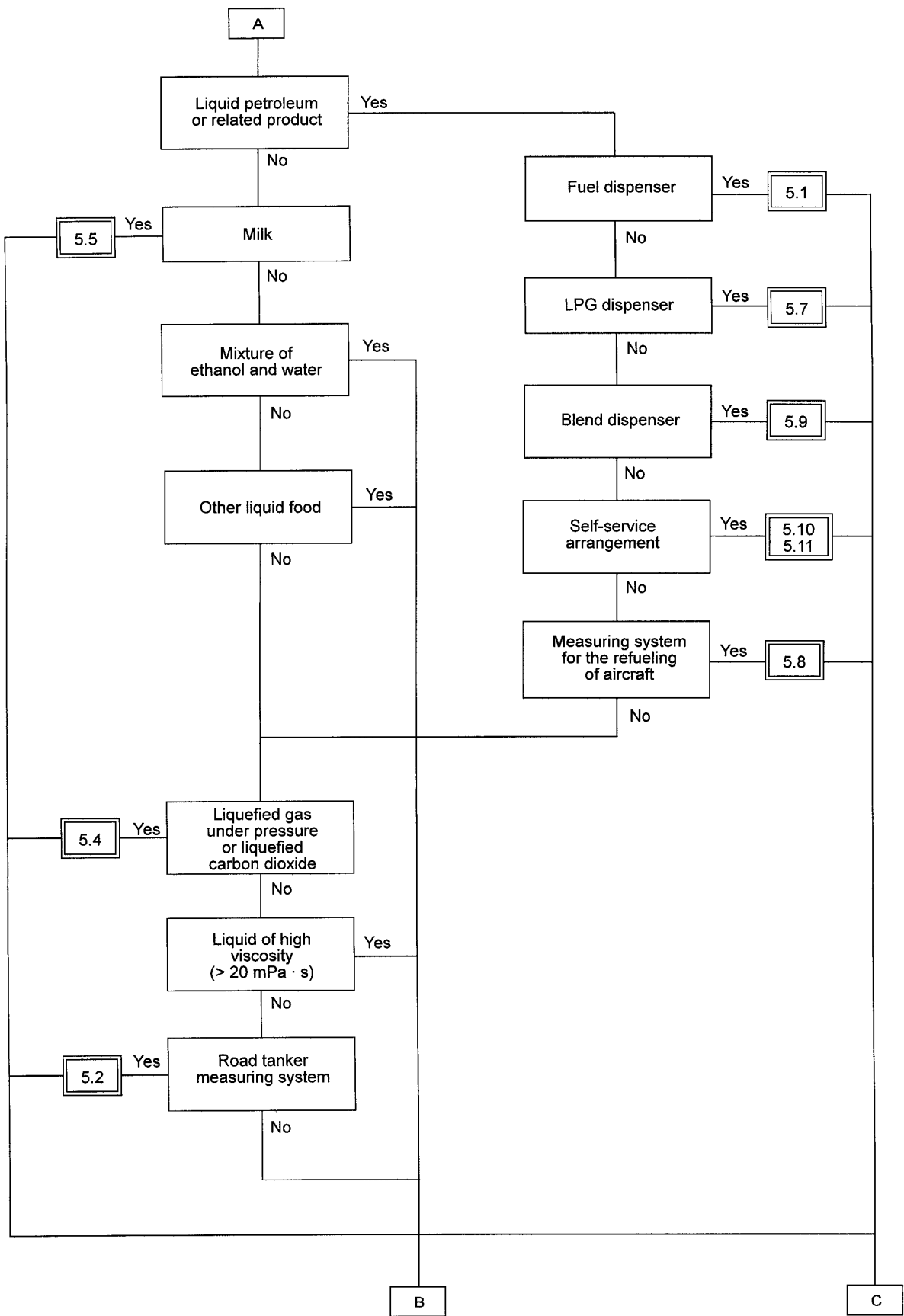
Endurance test T.4.7

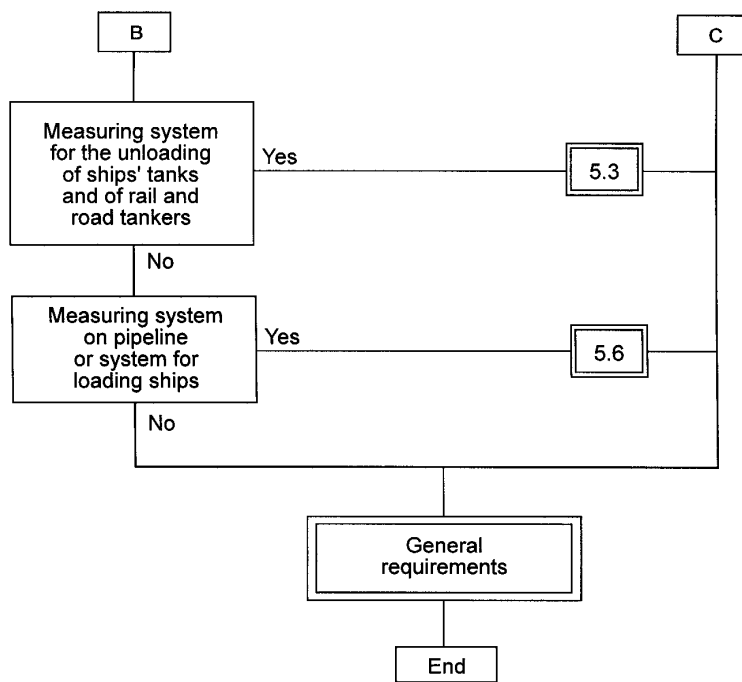
Uncertainty of the determination of an error T.4.8

ANNEX D
GUIDE FOR PATTERN APPROVAL
(Informative)

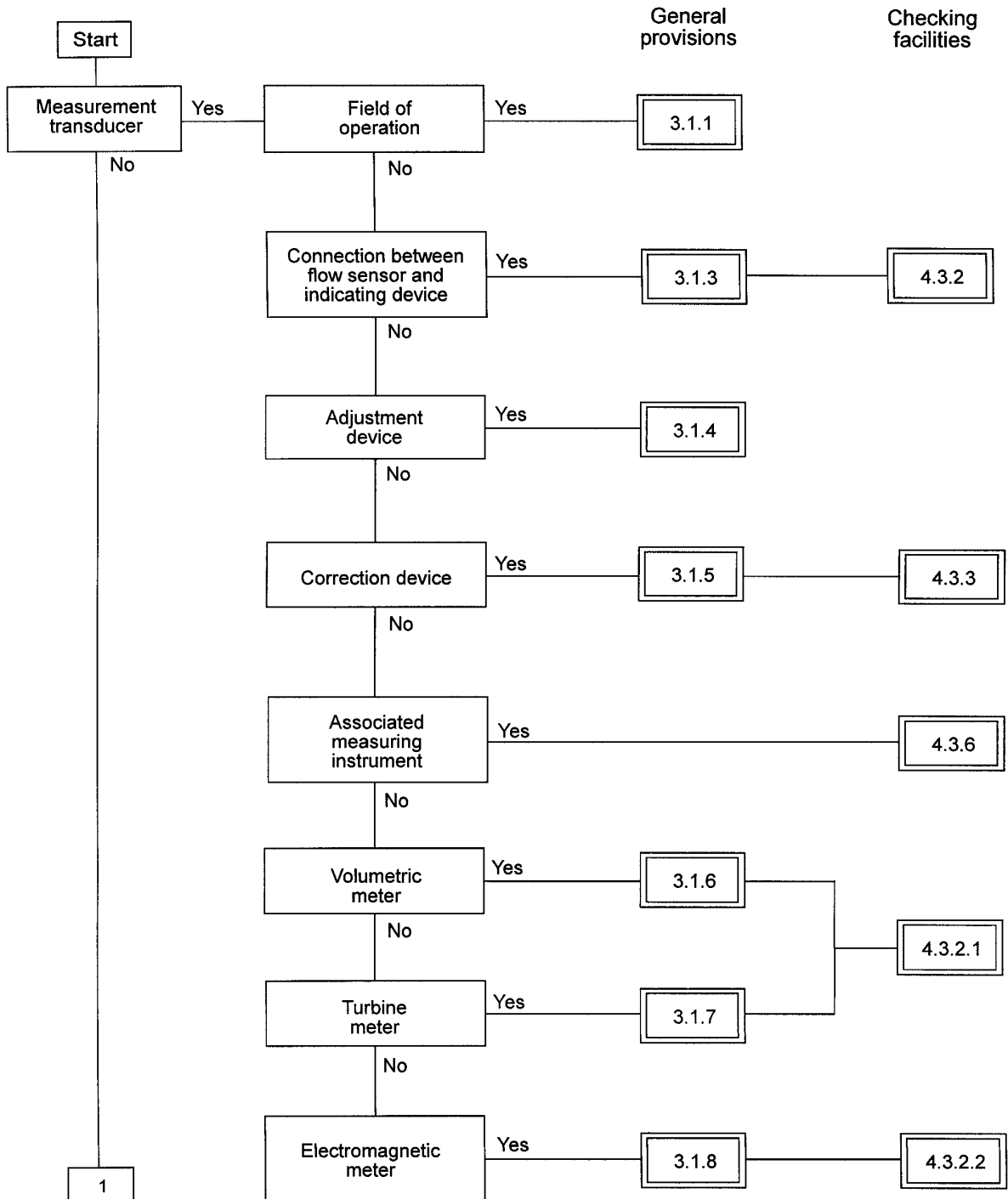
Field of application

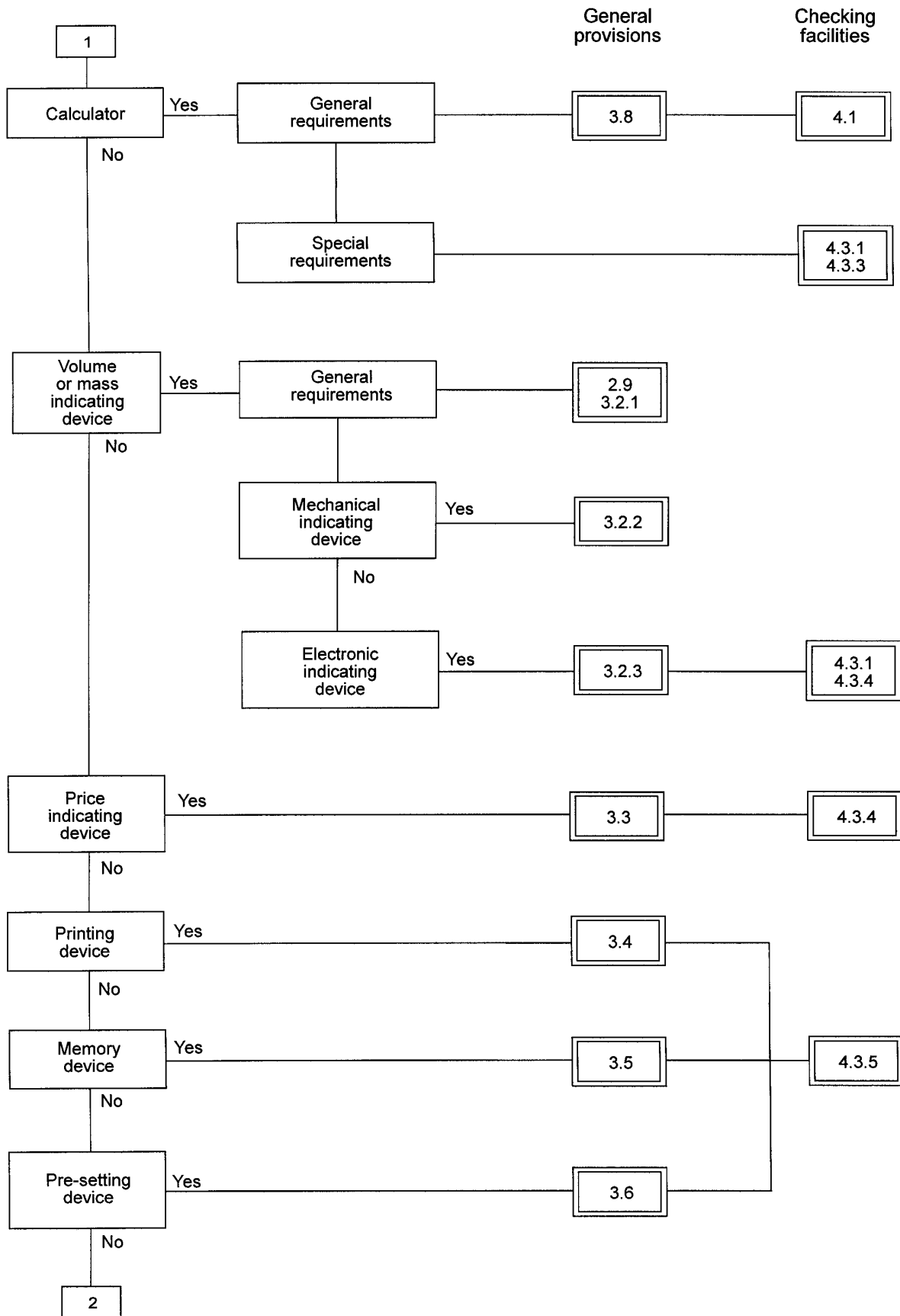


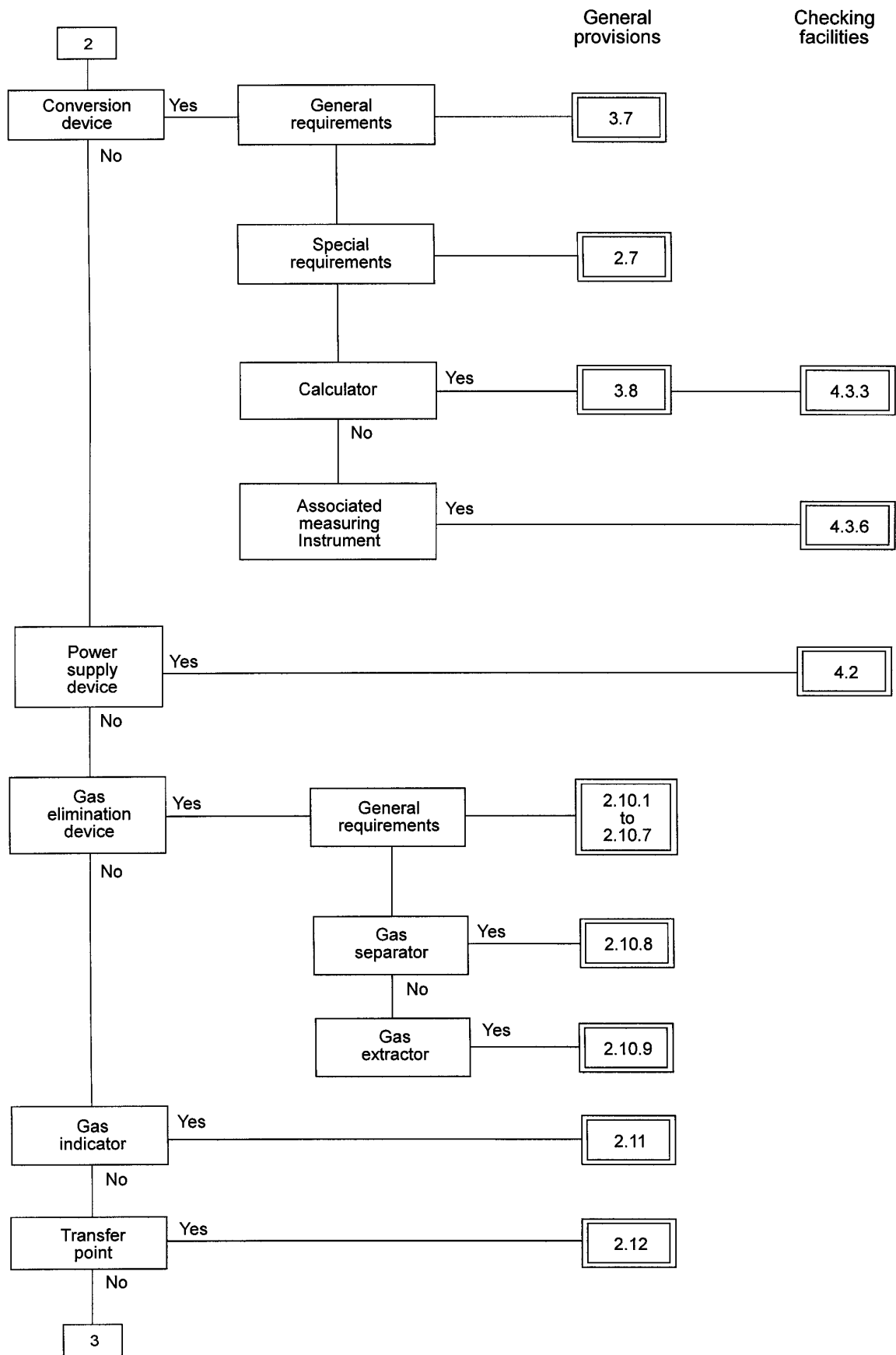


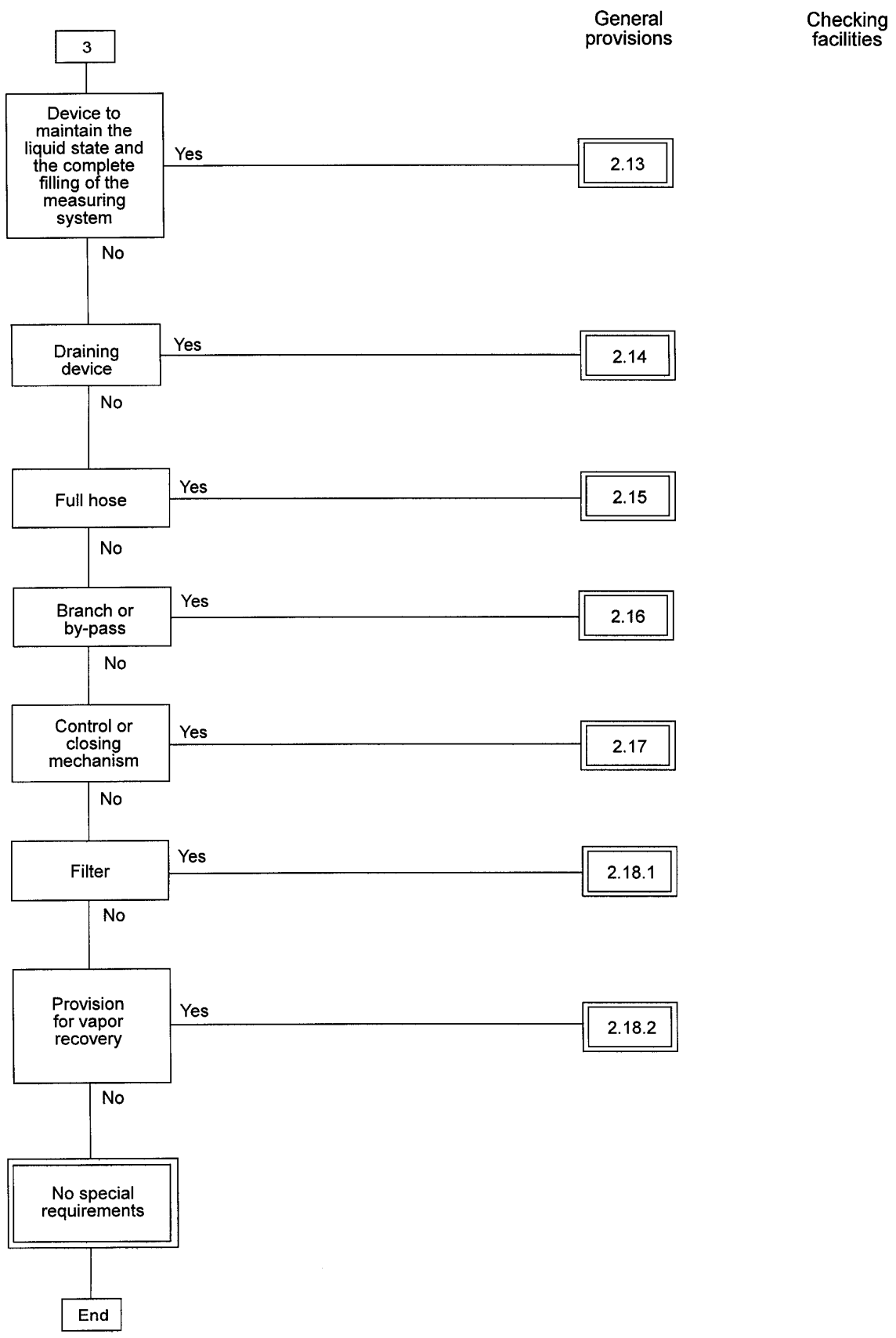


Devices of the measuring system









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