Australian Government

National Measurement Institute

NMI R 81
Dynamic Measuring Devices and Systems for Cryogenic Liquids

(OIML R 81:1998(E), IDT and OIML R 81:2006(E), IDT)

The English versions of international standards OIML R 81:1998 Dynamic Measuring Devices and Systems for Cryogenic Liquids and OIML R 81:2006 Annex D Test Report Format are adopted as an identical national standard with the reference number NMI R 81

measurement.gov.au

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National Measurement Institute
Bradfield Road, Lindfield, NSW 2070
PO Box 264, Lindfield, NSW 2070

T (61 2) 8467 3600
F (61 2) 8467 3610
W www.measurement.gov.au

1. SCOPE

NMI R 81 provides the metrological and technical requirements, the test procedures and a test report format for measuring devices and systems used for the dynamic measurement of cryogenic liquids used for trade in Australia.

2. CONTENTS

NMI R 81 is comprised of the following international recommendations published by the International Organisation of Legal Metrology (OIML):

- *OIML R 81. Dynamic Measuring Devices and Systems for Cryogenic Liquids* (1998); and
- *OIML R 81 Annex D. Test Report Format* (1996).

3. VARIATIONS AND INTERPRETATIONS

Minor variations apply to NMI R 81and are reproduced in full below. In the electronic pdf version of this publication, hover over (or right click) the highlighted text to view the variation.

- OIML R 117 is equivalent to NMI R 117.
- OIML R 105 is equivalent to NMI R 105.
- Refer to the following bibliography for the most recent edition of each publication.

IEC 60068-2-1 (2007) Environmental Testing. Part 2-1: Tests — Test A: Cold

IEC 60068-2-2 (2007) Environmental Testing. Part 2-2: Tests. Test B: Dry Heat

IEC 60068-2-6 (2007) Environmental Testing - Part 2-6: Tests - Test Fc: Vibration (Sinusoidal)

IEC 60068-2-28 (1990) has been superseded by IEC 60068-3-4 (2001) Environmental Testing. Part 3-4: Supporting Documentation and Guidance — Damp Heat Tests. The equivalent Australian standard is AS 60068.3.4 (2003)

IEC 60068-2-30 (2005) Environmental Testing. Part 2-30: Tests — Test Db: Damp Heat, Cyclic (12 h + 12 h Cycle)

IEC 61000-4-2 (2001) Electromagnetic Compatibility. Part 4-2: Testing and Measurement Techniques — Electrostatic Discharge Immunity Test. The equivalent Australian standard is AS/NZS 61000.4.2 (2002)

IEC 61000-4-4 (2004) Electromagnetic Compatibility. Part 4-4: Testing and Measurement Techniques — Electrical Fast Transient/Burst Immunity Test. Also refer to corrigendum 1 (2006). The equivalent Australian standard is AS/NZS 61000.4.4 (2006)

IEC 61000-4-11 (2004) Electromagnetic Compatibility. Part 4-11: Testing and Measurement Techniques — Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests. The equivalent Australian standard is AS/NZS 61000.4.11 (2005)

ISO 7637-1 (2002) Road Vehicles — Electrical Disturbances from Conduction and Coupling. Part 1: Definitions and General Considerations. Also refer to Amendment 1 (2008)

ISO 7637-2 (2004) Road vehicles — Electrical disturbances from conduction and coupling. Part 2: Electrical transient conduction along supply lines only

International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM) 3rd Edition (2007) OIML

INTERNATIONAL
RECOMMENDATION

OIML R 81

Edition 1998 (E)

Dynamic measuring devices and systems for cryogenic liquids

Dispositifs et systèmes de mesure dynamique de liquides cryogéniques

OIML R 81 Edition 1998 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Contents

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GRANDE IMPRIMERIE DE TROYES
130, rue Général-de-Gaulle, 10000 Troyes

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:

- **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;
- **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.

This publication - reference OIML R 81, edition 1998 (E) - was developed by the OIML subcommittee TC 8/SC 6 *Measurement of cryogenic liquids*. It was approved for final publication by the International Committee of Legal Metrology in 1997 and will be submitted to the International Conference of Legal Metrology in 2000 for formal sanction. It supersedes the previous edition dated 1989.

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

Bureau International de Métrologie Légale
11, rue Turgot - 75009 Paris - France
Telephone: 33 (0)1 48 78 12 82 and 42 85 27 11
Fax: 33 (0)1 42 82 17 27
E-mail: biml@oiml.org

Dynamic measuring devices and systems for cryogenic liquids

Section I

GENERAL

1 Scope

This Recommendation prescribes the metrological and technical requirements and test procedures for measuring devices and systems used for the dynamic measurement of cryogenic liquids.

This Recommendation establishes the conditions that measuring devices and systems shall meet to comply with the requirements of legal metrology services.

2 Application

2.1 This Recommendation applies to devices used for the measurement of cryogenic liquids such as, but not limited to oxygen, nitrogen, hydrogen, and argon. In principle, this Recommendation applies specifically for the quantitative measurements of cryogenic liquids whether installed in a permanent location, or mounted for use in transport and/or other containment vessels or tanks.

2.2 This Recommendation does not apply to the following:

- Devices used for dispensing liquefied petroleum gases (see OIML R 117 (1995) *Measuring systems for liquids other than water*);
- Mass flow meters (see OIML R 105 (1993) *Direct mass flow measuring systems for quantities of liquids*).

3 Terminology

The vocabulary provided below has been selected so that frequently used terms relating to cryogenic liquid measuring systems will be clearly defined.

3.1 Cryogenic liquid

A fluid with a boiling point of less than 120 K (–153 °C) under atmospheric pressure conditions, which has been liquefied by refrigeration.

3.2 Normal boiling point

That temperature at which a liquid vaporizes or boils at the atmospheric pressure of 101 325 Pa.

3.3 Reference (or working) standard

A standard, traceable to national standards, used for the verification of cryogenic liquid measuring devices and systems.

Note: This is usually referred to as “master meter” in this field.

3.4 Measuring system

A system that is comprised of the meter itself and all the ancillary devices and other equipment assembled to carry out the specified measurement task.

3.5 Meter

An instrument designed to measure continuously, memorize and display the quantity that passes through the measurement transducer.

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

3.6 Measurement transducer

A part of the meter that transforms the flow of the liquid to be measured into a signal(s) which is (are) sent to the calculator. It may either be autonomous or use an external power source.

Note: For the purpose of this Recommendation, the measurement transducer includes the flow or volume sensor.

3.7 Calculator

A part of the meter that receives the output signal from the transducer(s), transforms it and, if appropriate, stores in memory the results until they are used. Additionally, the calculator may be capable of communicating both ways with the peripheral equipment.

3.8 Indicating device

A part of the meter that is capable of displaying continuously the measurement results.

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

3.9 Ancillary device

A device intended to perform a particular function, directly involved in elaborating, memorizing, transmitting or displaying the measurement result. Examples are a printing device or a remote indicator.

3.10 Correction device

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

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

3.11 Conversion device

A device that 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 measured liquid (temperature, pressure, density, relative density, etc.) using associated measuring instruments, or associated values 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 the “conversion factor”.

3.12 Empty-hose type or dry-hose

A type of system in which the discharge hose is drained after each delivery.

3.13 Minimum measured quantity of a measuring system

The smallest quantity of liquid for which the measurement is metrologically acceptable.

Note: In a measuring system intended to deliver, this quantity is called the minimum delivery, and in those used for receiving operations it is called the minimum receipt.

3.14 Scale interval

The difference between the scale values corresponding to two successive scale marks.

3.15 Pre-setting device

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

3.16 Metering conditions

The conditions of the volume of the liquid at the point of measurement. For example, temperature and pressure.

3.17 Base conditions

The specified conditions of temperature and pressure to which the measured volume is converted.

Note: Although the term “reference conditions” is often used instead of “base conditions”, metering and base conditions (that refer only to the volume of the liquid to be measured or indicated), should not be confused with the “rated operating conditions” and “reference conditions” that apply to influence quantities.

3.18 Transfer point

The point at which the quantity of liquid measured is defined as being delivered or received.

3.19 Repeatability

The ability of a measuring instrument to provide closely similar indications for repeated applications of the same measurand under the same conditions of measurement. [VIM 5.27]

3.20 Intrinsic error

The error of a measuring system under reference conditions.

3.21 Initial intrinsic error

The error of the instrument as determined prior to any of the performance tests.

3.22 Uncertainty in 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: The components due to a meter verified or calibrated are notably linked to the resolution of its indicating device and to the periodic variation.

3.23 Fault*

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

3.24 Significant fault*

A fault the magnitude of which is greater than 20 % of the maximum permissible error (mpe) for the measured quantity.

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 facility;
- transitory faults being momentary variations in the indication, that cannot be interpreted, memorized, or transmitted as a measurement result;
- faults implying the impossibility of performing any measurement.

3.25 Influence quantity*

A quantity that is not the subject of the measurement but that can influence the value of the measurand or the indication of the measuring system (VIM 2.7).

3.26 Influence factor

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

3.27 Disturbance

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

3.28 Rated operating conditions*

Conditions of use, specifying the range of values of influence quantities for which the metrological characteristics are intended to be within the maximum permissible errors.

3.29 Permanent automatic checking facility (type P)*

An automatic checking facility that operates during the entire measurement operation.

3.30 Intermittent automatic checking facility (type I)*

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

3.31 Nonautomatic checking facility (type N)*

A checking facility that requires the intervention of an operator.

3.32 Reference conditions

A set of specified values of influence factors to ensure valid inter-comparisons of the results of a measurement.

3.33 Performance test

A test to verify that the measuring system under test (EUT) is capable of accomplishing its intended functions.

3.34 Primary indication

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

* Those definitions marked * are relevant to electronic measuring systems only.

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

3.35 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.

Note: The consumer can be any person. Generally, the consumer is the buyer but he can also be the seller.

4 Principles of the Recommendation

The determination of the accuracy of the measuring devices and systems evaluated under this Recommendation is based either on the use of a gravimetric test or the use of a master meter.

5 Units of measurement

5.1 The measurement results may be indicated in terms of:

- mass;
- liquid volume at the normal boiling point; or
- gas equivalent of a liquid volume at base conditions.

The indicated and recorded units shall be the kilogram, cubic metre or litre, or decimal multiples or sub-multiples thereof.

5.2 The density values given in the "Cryogenic liquids density tables" (see Annex C) shall be used for volume-mass computations of liquid argon, helium, hydrogen, nitrogen and oxygen. For other cryogenic liquids, tables applicable under national legal metrology authorities should be used.

Section II

METROLOGICAL REQUIREMENTS

6 Maximum permissible errors (mpe)

6.1 For pattern approval of a measuring system, the mpe is ± 2.5 % of the measured quantity.

6.2 For pattern approval of a meter (3.5), the mpe is ± 1.5 % of the measured quantity.

6.3 For pattern approval of components, the mpe is:

6.3.1 Temperature sensor: ± 1 K;
6.3.2 Pressure sensor: ± 50 kPa;
6.3.3 Density sensor: ± 5 kg/m^3;
6.3.4 Measurement transducer (3.6): ± 1 % of measured quantity;
6.3.5 For a calculator (3.7): ± 0.25 % of calculated quantity;
6.3.6 For a conversion device (3.11): ± 1 % of converted quantity.

6.4 For initial or subsequent verification of a measuring system under in-service conditions, the mpe is ± 2.5 % of the measured quantity.

6.5 Repeatability (3.19). The difference between the largest and smallest results of successive measurements shall not be greater than 1 % of the measured quantity.

7 Flowrates of a measuring system or a meter

7.1 The maximum and minimum authorized flowrates for a measuring system are specified by the manufacturer.

7.2 The ratio between the maximum and minimum flowrates of a meter shall be at least equal to 5.

8 Minimum measured quantity

8.1 The minimum measured quantity of the system shall be specified by the manufacturer.

8.2 The minimum measured quantity shall not be less than 100 scale intervals.

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

Section III

TECHNICAL REQUIREMENTS

9 Indicating devices (indicators)

9.1 General provisions

Indications shall be in legal units as described in 5.1 and shall be accompanied by the name or symbol of the unit. Indications that are not subjected to metrological control are allowed, provided that they cannot be confused with metrological information.

Reading of the indications shall be precise, easy and non-ambiguous when the indicating device comes to rest. If the indicating device comprises several elements, the installation shall be arranged in such a way that the readings of the measurand can be effected by simple juxtaposition of the indications of the different elements.

9.1.1 The scale interval of the indication shall be in the form of 1×10^n or 2×10^n or 5×10^n authorized units, n being a positive or negative whole number or zero.

9.1.2 The indicated units specified in subclause 5.1 shall be clearly defined.

9.1.3 The decimal mark shall appear distinctly.

9.2 Zero-setting device

9.2.1 An indicating device may be provided with a device which returns the indication to zero either by manual operation or by automatic means.

9.2.2 The zero-setting device shall not permit any alteration of the measurement result shown by the indicator (other than by making the result disappear and replacing it by zeros).

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

Indicating devices shall not be capable of being reset to zero during measurement.

9.3 Totalizing indicator

An indicator with a zeroing device may be equipped with a device for totalizing the different quantities shown successively by the indicator.

Note: The totalizing indicator shall be non-resettable.

10 Printing devices (printers)

10.1 A printing device may be connected to an indicator.

10.2 The printed scale interval shall be the same as the scale interval of the indicator.

10.3 The quantity printed shall be expressed in one of the units authorized for the indicator. The unit used or its symbols, and the decimal mark if any, shall be indicated on the ticket. The printed quantities shall be adequately and clearly defined.

10.4 The printer may print other information identifying the measurement such as serial number, date, place of measurement, type of liquid, etc.

10.5 If a printer allows repetition of the printing before a new measurement has started, copies shall be clearly marked as such, for example by printing “duplicate”.

10.6 For any quantity, the printed values shall be the same as those indicated.

10.7 Printed ticket. In the case of a volume indication, the ticket shall have printed on it the base conditions in terms of gas or liquid.

11 Measuring systems

11.1 Maintenance of liquid state

A measuring system shall be so designed and operated that the product being measured will remain in a liquid state during passage through the meter.

11.2 Adjusting means

11.2.1 Meters shall be provided with adjusting means that permit adjustments of the ratio between the quantity indicated and the actual quantity of liquid which has passed through the measuring device.

11.2.2 If the adjusting means modifies this ratio in a discontinuous manner, the consecutive values of the ratio shall not differ by more than 0.002.

11.2.3 Adjustments by means of a by-pass on the measuring device are prohibited.

11.3 Sealing

Sealing means shall be provided for those parts that can affect the accuracy of the measurement and for the parameters (e.g. correction and conversion) that can affect the measurement results.

11.3.1 Mechanical sealing

Mechanical sealing shall be carried out by means of lead and wire seals or other equally effective means.

11.3.2 Electronic sealing

When access to parameters that affect the determination of the results of a measurement is not protected by mechanical sealing means, the protection shall fulfill the following:

- access shall only be possible by such means as an alpha or numeric code, or “hard key”;
- an event counter (000–999) shall be provided to indicate that interventions have been made.

Note: The electronic sealing device should have a means of identifying if an intervention occurs and by whom. The responsible national body may require such means as the use of labels or an event logger that includes an event counter, date and time of intervention, and the identity and value of the parameter changed.

11.4 Memory devices

11.4.1 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 dispute. Devices used to read stored information are considered as included in the memory devices.

11.4.2 The medium on which the data are stored shall have sufficient permanency to ensure that the data are not corrupted under normal storage conditions.

11.4.3 When the storage is full, memorized data may be deleted when both the following conditions are met:

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

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

12 Discharge lines and valves

12.1 Vapor return lines

A vapor return line between the supplier’s tank and the customer’s tank shall not be permitted, unless necessary to complete a delivery.

12.2 Directional flow valve

A valve(s) or other means intended to prevent flow reversal, that is(are) automatic in operation shall be installed either on the outlet side of the meter or in the inlet line of the receiving tank.

12.3 Diversion of measured liquid

No means shall be provided by which any measured liquid can be diverted from the measuring element of the meter or the discharge line therefrom. However, a manually controlled outlet that may be opened for purging or draining the measuring system shall be permitted. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the measuring system.

12.4 Transfer point

12.4.1 The measuring systems shall incorporate a transfer point. This transfer point shall be located downstream of the meter in a delivery system, and upstream of the meter in a receiving system.

12.4.2 This transfer point may be in the form of a closing device combined with a system which ensures the evacuation of the discharge hose after each measuring operation.

12.5 Valves and control mechanisms

Check valves and closing mechanisms not used to define the measuring quantity shall, if necessary, have relief valves in order to dissipate any abnormally high pressures which may arise in the measuring system.

12.6 Discharge hose

The discharge hose of a measuring system shall be of the empty-hose type.

13 Markings

A measuring system shall be legibly and clearly marked with the following information:

- pattern approval mark;
- manufacturer's name or trademark;
- accuracy class (designation selected by the manufacturer), if appropriate;
- serial number and year of manufacture;
- maximum and minimum flowrates Q_{max} and Q_{min};
- maximum pressure P_{max};
- maximum and minimum temperature T_{max} and T_{min};
- minimum measured quantity.

Section IV

MEASURING SYSTEMS EQUIPPED WITH ELECTRONIC DEVICES

14 Measuring systems equipped with electronic devices

14.1 General requirements

14.1.1 Electronic measuring systems shall be designed and manufactured such that their errors do not exceed the maximum permissible errors as defined in clause 6 under rated operating conditions.

14.1.1.1 Interruptible electronic measuring systems shall be designed and manufactured such that, when they are exposed to the disturbances specified in B.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.

14.1.1.2 Non-interruptible electronic 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 B.4.

14.1.2 It is the responsibility of the manufacturer to decide whether a given pattern of measuring system is interruptible or not, taking account of the applicable rules of security.

14.1.2.1 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 subclause 14.1.1.2 apply.

14.1.3 Electronic measuring systems shall be provided with the checking facilities specified in subclause 14.3.

14.1.4 A pattern of a measuring system is presumed to comply with the requirements in subclauses 14.1.1 and 14.1.3 if it passes the inspection and tests specified in subclause 15.1.10.

14.1.5 When a significant fault occurs, measuring systems shall permit the retrieval of the information relating to the measured quantity, that is contained within the measuring system.

14.2 Power supply device

When the flow is interrupted during a failure of the principal power supply device:

- the measuring system shall be provided with an emergency power supply device to safeguard all the measuring functions during that failure, or
- data contained at the moment of the failure shall be saved and displayed on the resumption of power 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 (subclause 8.1).

14.3 Checking facilities

The checking facilities may either be permanent automatic (type P), intermittent automatic (type I) or non automatic (type N) as appropriate.

14.3.1 Action of checking facilities

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

14.3.1.1 Checking facilities of types I or P

a) for non-interruptible measuring systems (such as pipelines):

- 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 such time as 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 bullet point above is not applicable for the disturbances specified in B.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:

- 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.

14.3.2 Checking facilities for the measurement transducer

The object of these checking facilities after the presence of the transducer has been confirmed, is to verify its correct operation and the correctness of data transmission.

For all technologies, checking facilities shall provide a level of security equivalent to ISO 6551, part 3 Levels of security, 3.1.4 Level B, except for equipment with a cable length of 3 meters or less, for which 3.1.3 Level C applies.

Note: This requirement can be fulfilled without generating two pulses.

14.3.3 Checking facilities for the calculator (Type P or I)

The object of these checking facilities is to check if 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.

The correct value of all data relating to the measurement shall be checked by the instrument whenever these data are transmitted to an ancillary device through an interface.

In addition, the calculation system shall be provided with a means for controlling the continuity of the calculation program.

14.3.4 Checking facility for the indicating device (Type N)

The object of this checking facility is to verify that the primary indications are displayed and correspond to the data provided by the calculator.

In addition, it aims at verifying the presence of the indicating devices, when they are removable.

The checking facility for the indicating device shall include at least a visual checking of the display as follows:

- 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.

Note: The produced signal shall originate from the calculator.

14.3.5 Checking facilities for an ancillary device

Any ancillary device 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 validate the data transmitted by the calculator.

The object of the checking of a printing device is to ensure that the printing controls function properly so that output corresponds to the data transmitted by the calculator. The presence of paper shall be checked.

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

14.3.6 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 within a pre-determined measuring range.

Section V

METROLOGICAL CONTROLS

15 General requirements

The expanded uncertainty, U (for coverage factor $k = 2$), for the reference standard (including its indicating device), shall be less than 1/5 of the applicable maximum permissible errors of the measuring system under test for pattern approval and shall be less than 1/3 of the applicable maximum permissible errors of the measuring system under test for other verifications. (See *Guide to the Expression of Uncertainty in Measurement*, 1995).

The reference standards and their use may be the subject of other International Recommendations.

15.1 Pattern approval

15.1.1 General

Measuring systems subject to legal metrology control shall be subject to pattern approval. In addition, the constituent elements of a measuring system, mainly, but not limited to, those listed below, and sub-systems that may include more than one of these elements, may be subject to separate pattern approval:

- transducer;
- meter;
- electronic calculator (including the indicating device);
- conversion device;
- devices providing or memorizing measurements results;
- printer;
- temperature sensor;
- pressure sensor;
- density sensor.

15.1.2 Documentation

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

- description giving the technical characteristics and the principle of operation;
- 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 the way the correction parameters are determined;
- drawing showing the location of seals and verification marks;
- drawing of regulatory markings.

15.1.2.2 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.

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

15.1.3 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;
- metrological and technical characteristics;
- pattern approval mark;
- period of validity;
- environmental classification, if applicable (see Annex A);
- information on the location of marks for pattern approval, initial verification and sealing (for example, picture or drawing);
- list of documents which accompany 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).

15.1.4 Modification of an approved pattern

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

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

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

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

A new pattern approval has to be issued when the modified pattern no longer fulfills the provisions of the previous pattern approval.

15.1.5 Pattern approval of a meter or of a measurement transducer

15.1.5.1 A pattern approval may be given for a meter (3.5). It may also be given for the measurement transducer (as defined in 3.6) separately when it 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 also may be carried out on the whole measuring system.

Normally, tests are 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 such as 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 the computing and indicating devices have been subject to separate pattern approvals. 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 shall be applied to the output signal of the transducer to determine its errors.

15.1.5.2 Tests for maximum errors

15.1.5.2.1 The errors of the meter shall be determined for at least 6 flowrates (for example, at Q_{max}, 80 % Q_{max}, 70 % Q_{max}, 50 % Q_{max}, 40 % Q_{max} and at Q_{min}), 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), as specified in 6.2. The repeatability shall meet the requirements of 6.5.

15.1.5.2.2 The following tests shall also be carried out:

- test for maximum errors (15.1.5.2.1) at minimum measured quantity, if practical;
- tests with flow disturbances, if appropriate.

15.1.5.3 Endurance test

An endurance test should be carried out at the maximum flowrate of the meter, with the liquid the meter is intended to measure or with a liquid of 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.

An endurance test shall be conducted according to A.1.5.

After the endurance test, the meter is again subject to a new accuracy test.

15.1.6 Pattern approval of an electronic calculator

When an electronic calculator is submitted for a separate pattern approval, tests are conducted on the calculator on its own, simulating different inputs with appropriate standards. For this purpose, the error obtained on the indication of the result is calculated by considering that the true value is computed with standard methods of calculation using the simulated quantities applied to inputs of the calculator.

15.1.7 Pattern approval of a conversion device

When a conversion device is submitted for a separate pattern approval, either of the procedures specified in 15.1.7.1 or 15.1.7.2 may be used.

15.1.7.1 General case

It is necessary to verify that the conversion device connected to all its associated measuring instruments complies with the provisions of 6.3.6. For that purpose, the volume to be converted is considered to be without error when at metering conditions. In the case of an electronic conversion device, it is necessary to perform the examination and tests described in 15.1.10.

15.1.7.2 Electronic conversion device

Instead of the procedure in 15.1.7.1, it is also possible:

- to verify separately the accuracy of associated measuring instruments (see 6.3.1, 6.3.2, and 6.3.3);
- to verify that the provisions of 15.1.6 are fulfilled; and
- to perform the examinations and tests described in 15.1.10.

15.1.8 Pattern approval of an ancillary device

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

For any measured quantity relating to the same measurement, the indications provided by the various devices shall not deviate one from another.

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

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

When at least one of the signals of the primary indication information is analogue, the device shall be tested associated with another device for which this Recommendation provides maximum permissible errors.

When all the signals of the primary indication are digital, the above provision may be applied. However, when the inputs and outputs of the device are available, it can be tested separately; in this case, only errors due to the testing method are allowed and the device shall present no other error.

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.

15.1.9 Pattern approval of a measuring system

The pattern approval of a measuring system consists of verifying that the measuring system, the meter, and

the constituent elements meet the corresponding requirements, and that the constituent elements are compatible with each other.

For the meter it is possible to verify that its own constituent elements meet the corresponding requirements and that they are compatible with each other.

The tests to carry out for the pattern approval of a measuring system may be determined on the basis of the pattern approvals already granted for the constituent elements of the system.

Note: Constituent elements may be subject to separate pattern approval when they are intended to be part of several patterns of measuring systems. This is advantageous when the various measuring systems are manufactured by different manufacturers and when the bodies responsible for the various pattern approvals are different.

15.1.10 Pattern approval of an electronic device

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

15.1.10.1 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. It includes:

- an examination of the mode of construction and of the electronic sub-systems and components used, to verify their appropriateness for the intended use;
- considering faults likely to occur, to verify that in all considered cases these devices comply with the provisions of subclause 14.3;
- verification of the presence and effectiveness of the test device(s) for the checking facilities.

15.1.10.2 Performance tests

These tests aim at verifying that the measuring system complies with the provisions of subclause 14.1.1 as regards influence quantities. These tests are specified in Annex B.

a) Performance under the effect of influence factors

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

15.1.10.3 Equipment under test (EUT)

Tests are carried out on the complete measuring system where size and configuration permit, except where there are other provisions in the Annex.

Otherwise, electronic devices shall be submitted separately to tests, in the form of equipment comprising at least the following devices:

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

This equipment 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.

15.2 Initial verification

15.2.1 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;
- is carried out in two stages in all other cases.

First stage: pertains to the flow sensor, on its own or fitted with its associated ancillary devices, or possibly included in a sub-system. The first stage tests 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 to those that the system is intended to measure.

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

Second stage: pertains to the measuring system under actual working conditions. 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 body in charge of verification 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 to verify the presence and correct operation of checking facilities by the use of test devices as specified in subclause 14.3.

15.2.2 Tests

15.2.2.1 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 pattern);
- 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.

15.2.2.2 When initial verification takes place in one stage, all the tests mentioned in subclause 15.2.2.1 shall be performed.

15.2.2.3 The maximum permissible errors on initial verification shall meet the requirements of 6.4.

15.3 Subsequent verification

15.3.1 The procedures and requirements for subsequent verification of a measuring system may be identical to the initial verification.

15.3.2 If the protective seals of the meter and/or the ancillary devices are intact, a complete examination of the measuring system may not be necessary. To determine the error curve, tests should be conducted at least with a volume of liquid equal to the minimum measured quantity, and at least at 60 % of the maximum flowrate of the meter.

15.3.3 The maximum permissible errors on subsequent verification shall meet the requirements of 6.4.

16 Test conditions

16.1 General

Care shall be exercised to reduce vaporization and volume changes to a minimum. When testing gravimetrically, the weigh tank and transfer systems shall be pre-cooled to the temperature of the liquid prior to the start of the test to avoid the venting of vapor from the vessel being weighed.

16.1.1 Test liquid

The system shall be tested with the liquid to be measured, except that another cryogenic liquid may be used if evidence can be provided indicating that the test liquid to be used will provide equivalent performance under the required test conditions.

16.1.2 Test quantities

The minimum test quantity shall normally not be less than 300 scale intervals of the meter under test and 1000 scale intervals of the master meter, whichever is the smallest.

However, the test quantity for determining the error near the minimum measured quantity shall be equal to the minimum measured quantity.

Note 1: For a flying start-stop test (that is, a test to determine the time interval required to collect a preselected weight of liquid), when the

uncertainty in the standard can be maintained as specified in clause 15, smaller test quantities may be used. However, in no case shall the test quantity be less than 140 kg for devices having a maximum flowrate of at least 50 l/min, as specified by the manufacturer.

Note 2: When testing with a master meter, the test quantity shall be equal to at least the amount delivered in 3 minutes at its maximum discharge rate. When testing uncompensated meters in a continuous recycle flow, appropriate corrections shall be applied if product conditions are abnormally affected by this test mode.

16.1.3 Temperature and pressure data

The temperature and pressure of the measured liquid shall be recorded during the test for the determination of density or volume correction factors, when applicable.

ANNEX A

TEST PROCEDURES

Performance tests - general

These tests should be applied uniformly by the legal metrology services and are intended to ensure that the instruments can perform and function as prescribed under rated conditions of use.

When the effect of one influence quantity or disturbance is being evaluated, all other influence quantities or disturbances are to be held relatively constant, at a value close to normal.

Relatively stable test conditions for each of the parameters of the liquid are as follows:

temperature: ± 5 °C;
pressure: ± 20 % not to exceed 200 kPa (2 bar);
flowrate: ± 5 %.

The instrument should be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics (see 16.1.1).

A.1 Pattern approval tests

The gravimetric test method is recommended; other suitable methods may be used provided the requirements of A.1.1 are met.

A.1.1 Uncertainty

The expanded uncertainty, U (for coverage factor $k = 2$), for the reference standard (including its indicating device), shall be less than 1/5 of the applicable maximum permissible errors of the measuring system under test for pattern approval. (See *Guide to the Expression of Uncertainty in Measurement*, 1995).

A.1.2 Quantities

Any test quantity shall be equal to or greater than the minimum measured quantity (see 16.1.2).

A.1.2.1 Repeatability tests conducted to determine compliance with 6.5

Repeatability tests shall be conducted with quantities equal to or greater than five times the minimum measured quantity.

A.1.3 Liquids

The EUT should be tested with sufficient liquid or liquids with similar characteristics over the range of liquids for which the manufacturer has requested approval (see 16.1.1 and 16.1.2).

A.1.4 Flow rates for tests of maximum errors

The EUT shall be tested according to the requirements given in 15.1.5.2.

A.1.5 Endurance

An endurance test shall be conducted as follows (see 15.1.5.3):

- an accuracy test shall be conducted prior to the endurance test;
- as far as possible, the meter is subjected to an endurance test on a test bench. However it is accepted that the meter be temporarily mounted in a measuring system in normal operation. It is then necessary that the nominal operating flowrate of the measuring system be more than 0.8 Q_{max};
- The endurance test shall be conducted for 100 hours in one or several periods at a flowrate from 80 % Q_{max} to Q_{max};
- After the 100 hour test, an accuracy test shall be conducted with the same quantity as above. The test results shall not vary from the first test by more than 1.5 % of the measured quantity, without any adjustment or correction.

A.2 Initial and subsequent verification tests

The verification of the measuring system may be conducted by the gravimetric or volumetric method, or with a master meter.

A.2.1 Uncertainty

The expanded uncertainty, U (for coverage factor $k = 2$), for the reference standard (including its indicating

device), shall be less than 1/3 of the applicable maximum permissible errors of the measuring system under test for initial and subsequent verifications. (See *Guide to the Expression of Uncertainty in Measurement*, 1995).

A.2.2 Quantities

Any test quantity shall be equal to or greater than the minimum measured quantity (see 16.1.2).

A.2.3 Flow rates for tests of maximum errors

The EUT shall be tested at the maximum flowrate achievable under the conditions of installation, the minimum flowrate marked on the instrument, and at least one intermediate flowrate. At least one test shall be conducted at each flowrate (see 15.1.5.2.1).

Note: For subsequent verification, see subclause 15.3.2.

ANNEX B

TEST PROCEDURES

Performance tests - Applicable to electronic equipment

B.1 General

This Annex specifies the tests intended to ensure that electronic measuring systems perform and function as prescribed in a specified environment and under specified conditions. Where appropriate, each test indicates the reference conditions under which the intrinsic error is determined.

These tests supplement those in Annex A.

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.

When the effect of a disturbance is being evaluated, no other disturbance shall be present and all influence quantities shall be held relatively constant, at values close to reference conditions.

B.2 Severity levels (see OIML D 11)

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

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

- class B for a fixed instrument installed in a building;
- class C for a fixed instrument installed outdoors;
- class I for a mobile instrument, especially those mounted on a truck.

The applicant for pattern approval may define specific environmental conditions for the future use of the equipment in the documentation supplied to the metrology service. In this case, the metrology service carries out the tests at severity levels corresponding to these specific environmental conditions. If pattern approval is granted, the data plate shall indicate the corresponding limits of use. Conditions of use for which the instrument is approved shall be provided by the manufacturers. The metrology service shall verify that the conditions of use are met.

B.3 Reference conditions

Ambient temperature:	15 °C to 25 °C;
Relative humidity:	45 % to 75 %;
Atmospheric pressure:	86 kPa to 106 kPa;
Power voltage:	Nominal voltage;
Power frequency:	Nominal frequency.

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

B.4 Performance tests (refer to the summary table)

Notes: Simulated tests

Except for B.4.3 and B.4.4 (non-operational tests), the tests may be conducted by simulating the flow without any actual product passing through the measuring system, if it can be shown that the flow sensor is not affected by the test conditions.

Note 1 Simulated flow must produce an output or outputs from the measuring system corresponding to an actual flowrate between the minimum and maximum flowrates for the system.

Note 2 While flow is being simulated, it must be possible to ascertain that the flow measurement capabilities of the system are fully operational.

Summary of performance tests

Test		*Nature of the influence quantity*	*Severity level (reference OIML D 11)*		
			B	C	I
B.4.1	Dry heat	Influence factor	2	3	3
B.4.2	Cold	Influence factor	2	3	3
B.4.3	Damp heat, cyclic	Influence factor	1	2	2
B.4.4	Vibration (sinusoidal)	Influence factor	-	-	3
B.4.5.1	AC power supply voltage variations	Influence factor	1	1	1
B.4.5.2	DC power supply voltage variations	Disturbance	1	1	1
B.4.6	Short time power reductions	Disturbance	1a & 1b	1a & 1b	1a & 1b
B.4.7	Bursts	Disturbance	2	2	2
B.4.8	Electrostatic discharge	Disturbance	1	1	1
B.4.9	Electromagnetic susceptibility	Disturbance	2	2	2
B.4.10	Perturbations on DC voltage powered instruments	Disturbance	2	2	2

B.4.1 Dry heat

Test method

Dry heat (non condensing).

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under conditions of high temperature.

References

IEC Publication 60068-2-2, 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 60068-3-1, first edition, 1974 and first supplement 60068-3-1A, 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 60068-1, 1988.

Test procedure in brief

The test consists of exposing the EUT to a temperature of 55 °C (class 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 for at least one flowrate (or simulated flowrate):

- at the reference temperature of 20 °C following conditioning;
- at the temperature of 55 °C (class C or I) or 40 °C (class B), 2 hours following temperature stabilization;
- after recovery of the EUT at the reference temperature of 20 °C.

Test severity

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 indications shall be within the maximum permissible errors.

B.4.2 Cold

Test method

Cold.

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under conditions of low temperature.

References

IEC Publication 60068-2-1, 1990, Basic environmental testing procedures, Part 2: Tests, Test A: Cold, Section 3 - Test Ad: Cold for heat dissipating EUT with gradual change of temperature.

Background information concerning cold tests is given in IEC Publication 60068-3-1, first edition 1974 and first supplement 60068-3-1A, 1978 Part 3: Background information, section one: Cold and dry heat tests. General background information on basic environmental testing procedures is given in IEC Publication 60068-1, 1988.

Test procedure in brief

The test consists of exposing the EUT to a temperature of –25 °C (class C or I) or –10 °C (class B) under "free air" conditions for a 2 hour period after the EUT has reached temperature stability. The EUT shall be tested for at least one flowrate (or simulated flowrate):

- at the reference temperature of 20 °C following conditioning;
- at a temperature of –25 °C or –10 °C, 2 hours following temperature stabilization;
- after recovery of the EUT at the reference temperature of 20 °C.

Test severity

1) Temperature: severity level 2: –10 °C;
severity level 3: –25 °C.

2) Duration: 2 hours.

Number of test cycles

One cycle.

Maximum allowable variations

All functions shall operate as designed.

All indications shall be within the maximum permissible errors.

B.4.3 Damp heat, cyclic

Test method

Damp heat, cyclic (condensing).

Object of the test

To verify compliance of the electronic measuring instrument with the provisions in subclause 14.1.1 under conditions of high humidity when combined with cyclic temperature changes.

References

IEC Publication 60068-2-30, second edition, 1980, Basic environmental testing procedures, Part 2: Tests, test Db: Damp heat, cyclic (12 h + 12 h cycle), test variant 2.

Background information concerning damp heat tests is given in IEC Publication 60068-2-28, third edition, 1990: Guidance for damp heat tests.

Test procedure in brief

The test consists of exposing the non-operational EUT (power supplied and on) to cyclic temperature variations between 25 °C and the upper temperature of 55 °C (class C or I) or 40 °C (class B), maintaining the relative humidity above 95 % during the temperature changes and during the phases at low temperature, and at 93 % at the upper temperature phases. Condensation should occur on the EUT during the temperature rise. The standard atmospheric stabilizing period before and recovery after the cyclic exposure are indicated in IEC Publication 60068-2-30. After recovery, a performance test under reference conditions for at least one flowrate (or simulated flowrate) is conducted.

Test severity

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

All functions shall operate as designed.

All indications shall be within the maximum permissible errors.

B.4.4 Vibration

Test method

Sinusoidal vibration.

Object of the test

To verify compliance of the electronic measuring instrument to the provisions in subclause 14.1.1 under conditions of sinusoidal vibration.

References

IEC Publication 60068-2-6, 1995, Basic environmental testing procedures, Part 2: Tests. Test Fc: Vibration (sinusoidal).

Test procedure in brief

The non-operational 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. After the vibration test, a performance test under reference conditions for at least one flowrate is conducted.

Test severity

1) Frequency range:	10 Hz–150 Hz.
2) Max. acceleration level:	20 $m \cdot s^2$.

Number of test cycles

20 sweep cycles per axis.

Maximum allowable variations

All functions shall operate as designed.

All indications shall be within the maximum permissible errors.

B.4.5 Power voltage variation

B.4.5.1 AC power supply

Test method

Variation in AC mains power supply (single phase).

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under conditions of varying AC mains power supply.

Test procedure in brief

The test consists of exposing the EUT to power voltage variations, while the EUT is operating under normal atmospheric conditions. The EUT shall be tested for at least one flowrate (or simulated flowrate), at the upper and lower voltage limits.

Test severity

Mains voltage: upper limit: U_{nom} + 10 %;
lower limit: U_{nom} – 15 %.

Number of test cycles

One cycle.

Maximum allowable variations

All functions shall operate as designed.

All indications shall be within the maximum permissible errors.

B.4.5.2 DC power supply

Test method

Variation in DC power supply.

Object of the test

To verify compliance with the provisions subclause 14.1.1 under conditions of varying DC power supply.

Test procedure in brief

The test consists of exposing the EUT to power voltage variations, while the EUT is operating under normal atmospheric conditions. The EUT shall be tested at least one flowrate (or simulated flowrate), at the upper and lower voltage limits

Test severity

DC voltage: upper limit: U_{nom} + 10 %;
lower limit: U_{nom} – 15 %.

Number of test cycles

One cycle.

Maximum allowable variations

All functions shall operate as designed.

All indications shall be within the maximum permissible errors.

B.4.6 Short time power reduction (not applicable to systems with a DC power supply)

Test method

Short time interruptions and reductions of mains voltage.

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under conditions of short time mains voltage interruptions and reductions.

References

IEC Publication 61000-4-11 (1994), Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques - Section 11. Voltage dips, short interruptions and voltage variations immunity tests. Section 5.2 (Test levels - Voltage variation). Section 8.2.2 (Execution of the test-voltage variation).

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 10 ms, and from nominal voltage to 50 % of nominal for a duration equal to 20 ms. The mains voltage interruptions and reductions shall be repeated ten times with a time interval of at least 10 seconds. The EUT shall be tested for at least one flowrate (or simulated flowrate).

Test severity

100 % voltage interruption for a period equal to 10 ms;
50 % voltage reduction for a period equal to 20 ms.

Number of test cycles

Ten tests with a minimum of 10 seconds between tests.

Maximum allowable variations

a) For interruptible measuring systems, either the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24 or the measuring system shall detect and act upon a significant fault, in compliance with subclause 14.1.1.

b) For non-interruptible measuring systems, the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24.

B.4.7 Bursts (not applicable to systems with a DC power supply)

Test method

Electrical bursts.

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under conditions where electrical bursts are superimposed on the mains voltage.

References

IEC Publication 61000-4-4 (1995), Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques - Section 4: Electrical fast transient/burst immunity test. Basic EMC publication.

Test procedure in brief

The test consists of subjecting the EUT to bursts of double exponential wave-form 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 these bursts shall be applied during the same measurement or simulated measurement.

Test severity

Amplitude (peak value) 1000 V.

Number of test cycles

At least 10 positive and 10 negative randomly phased bursts shall be applied at 1000 V.

Maximum allowable variations

a) For interruptible measuring systems, either the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24 or the measuring system shall detect and act upon a significant fault, in compliance with subclause 14.1.1.

b) For non-interruptible measuring systems, the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24.

B.4.8 Electrostatic discharge

Test method

Electrostatic discharge (ESD).

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under conditions of electrostatic discharges.

References

IEC Publication 61000-4-2 (1995) Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques - Section 2: Electrostatic discharge immunity test. Basic EMC Publication.

Test procedure in brief

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 150 ohms to surfaces which are normally accessible to the operator.

In the case of contact discharges, the tip of the discharge electrode shall touch the EUT before the discharge switch is operated.

In the case of painted surfaces covering a conducting substrate, the following procedure shall be adopted:

If the coating is not declared to be an insulating coating by the instrument manufacturer, then the point tip of the generator shall penetrate the coating so as to make contact with the conducting substrate. Coating declared as insulating by the manufacturer shall only be submitted to the air discharge. The contact discharge test shall not be applied to such surfaces.

In the case of air discharges, the round discharge tip of the discharge electrode shall be approached as fast as possible (without causing mechanical damage) to touch the EUT. After each discharge, the ESD generator (discharge electrode) shall be removed from the EUT. The generator is then retriggered for a new single discharge. This procedure shall be repeated until the discharges are completed. In the case of an air discharge test, the discharge switch which is used for contact discharge, shall be closed.

Test severity

Air discharge: up to and including 8 kV;
Contact discharge: up to and including 6 kV.

Number of test cycles

At least ten discharges shall be applied at intervals of at least 10 seconds between discharges, during the same measurement or simulated measurement.

Maximum allowable variations

a) For interruptible measuring systems, either the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24 or the measuring system shall detect and act upon a significant fault, in compliance with subclause 14.1.1.

b) For non-interruptible measuring systems, the differences between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24.

B.4.9 Electromagnetic susceptibility

Test method

Electromagnetic fields (radiated).

Object of the test

To verify compliance with the provisions in subclause 14.1.1 under various electromagnetic fields.

References

IEC Publication 61000-4-3 (1995) Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques - Section 3: Radiated, radio-frequency, electromagnetic field immunity test.

Test procedure in brief

The EUT shall be exposed to an electromagnetic field strength as specified by the severity level during the measurement or simulated measurement. The field strength can be generated in the following ways:

- the strip line is used at frequencies below 30 MHz (in some cases 150 MHz) for smaller EUT's;
- the long wire is used at frequencies below 30 MHz for larger EUT's;
- dipole antennae or antennae with circular polarization placed 1 m from the EUT are used at high frequencies.

The specified field strength is established prior to testing (without the EUT in the field).

The field is generated in two orthogonal polarizations and the frequency range is scanned slowly.

If antennae with circular polarization, i.e. log-spiral or helical antennae are used to generate the electromagnetic field, a change in the position of the antennae is not necessary.

When the test is carried out in a shielded enclosure, to comply with international law prohibiting interference to radio communications, anechoic shielding may be necessary to reduce reflection from the walls.

Test severity

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

Maximum allowable variations

a) For interruptible measuring systems, either the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24 or the measuring system shall detect and act upon a significant fault, in compliance with subclause 14.1.1.

b) For non-interruptible measuring systems, the difference between the quantity indication during the test and the indication under reference conditions shall not exceed the values given in 3.24.

B.4.10 Perturbations on DC voltage powered instruments

Electronic measuring systems with DC voltage power supply shall not be subjected to the tests B.4.5.1 *AC power supply*, B.4.6 *Short time power reduction*, and B.4.7 *Bursts*. They shall meet the following:

1 General

When the power supplied is less than –15 % U_{nom}, or greater than +10 % U_{nom}, during a measurement the EUT shall either indicate within mpe or not provide an indication that could be construed as measurement value.

2 For instruments powered by the battery of a vehicle

Test pulses 1, 2, and 3 as specified in ISO 7637: Road vehicles. Electrical disturbance by conduction and coupling, Part 1 or Part 2 as appropriate shall be effected. The pulses are to be repeated for as long as necessary to complete the test.

The pattern approval certificate shall indicate at least Severity Level II.

ANNEX C

TABLES OF DENSITY FOR LIQUID ARGON, HELIUM, HYDROGEN, NITROGEN AND OXYGEN

The tables on the following pages give the values in SI units of the density as a function of temperature and pressure for liquid argon, helium, hydrogen, nitrogen and oxygen. Two tables are given for each fluid:

- the "-a" tables give the values of vapor pressure, density and volume per mass unit as a function of temperature for the so-called saturated liquid (liquid under its vapor pressure);
- the "-b" tables give the values of density as a function of temperature for the so-called subcooled liquid (liquid under pressure).

Ranges of the tables:

Table 1 – Argon

Temperature from 85 K to 150 K and pressure up to 4 MPa;

Table 2 – Helium

Temperature from 4 K to 5.14 K and pressure up to 0.22 MPa;

Table 3 – Hydrogen

Temperature from 19.4 K to 32.8 K and pressure up to 1.2 MPa;

Table 4 – Nitrogen

Temperature from 75 K to 126 K and pressure up to 3 MPa;

Table 5 – Oxygen

Temperature from 88 K to 154 K and pressure up to 4 MPa.

The tables were drawn up from the computer programs which were used to prepare similar tables for the United States Compressed Gas Association and which are reported in [1]. The data provided with these tables were prepared by the Thermophysics Division of the National Institute of Standards and Technology (former National Bureau of Standards) and are consistent with the data reported in [1] and in the source documents [2] and [3]. The computer programs which were used to prepare these tables are available from the NIST Office of Standard Reference Data [4].

References applicable to Annex C

[1] Younglove, B.A., Tables of Industrial Gas Container Contents and Density for Oxygen, Argon, Nitrogen, Helium and Hydrogen. Nat. Bur. Stand. (USA) Tech. Note No. 1079, June 1985. 195 p.

[2] McCarty, R.D., Interactive Fortran IV Computer Programs for the Thermodynamic and Transport Properties of Selected Cryogens (Fluids Pack). Nat. Bur. Stand. (USA) Tech. Note No. 1025, October 1980. 112 p.

[3] Younglove, B.A., Thermophysical Properties of Fluids. I. Argon, Ethylene, Parahydrogen, Nitrogen, Trifluoride and Oxygen. J. Phys. Chem. Ref. Data 11, No. 4, 1982.

[4] For magnetic tape, order NIST Standard Reference Data Base 5 for helium properties and Data Base 6 for the other fluids from the Office of Standard Reference Data, A320 Physics Building, National Institute of Standards and Technology, Gaithersburg, MD 20899, USA.

Note: The National Institute of Standards and Technology (NIST) has prepared these tables at the request of the Organisation Internationale de Métrologie Légale (OIML). Since they were prepared under the auspices of the United States Government, they are not subject to copyright.

TABLE 1–a

ARGON

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
85.0	.0790	1407.0	.7107
86.0	.0883	1401.0	.7138
87.0	.0983	1394.9	.7169
88.0	.1093	1388.8	.7200
89.0	.1211	1382.6	.7233
90.0	.1339	1376.4	.7265
91.0	.1477	1370.1	.7299
92.0	.1626	1363.8	.7332
93.0	.1785	1357.4	.7367
94.0	.1956	1351.0	.7402
95.0	.2139	1344.5	.7438
96.0	.2335	1337.9	.7474
97.0	.2543	1331.3	.7511
98.0	.2765	1324.7	.7549
99.0	.3001	1318.0	.7588
100.0	.3252	1311.2	.7627
101.0	.3518	1304.3	.7667
102.0	.3799	1297.4	.7708
103.0	.4097	1290.4	.7749
104.0	.4411	1283.4	.7792
105.0	.4743	1276.3	.7835
106.0	.5092	1269.1	.7880
107.0	.5459	1261.9	.7925
108.0	.5846	1254.5	.7971
109.0	.6252	1247.1	.8019
110.0	.6678	1239.6	.8067
111.0	.7124	1232.0	.8117
112.0	.7591	1224.4	.8167
113.0	.8080	1216.6	.8219
114.0	.8592	1208.8	.8273
115.0	.9126	1200.8	.8328
116.0	.9683	1192.8	.8384
117.0	1.0264	1184.6	.8441
118.0	1.0870	1176.4	.8501
119.0	1.1501	1168.0	.8562
120.0	1.2158	1159.4	.8625
121.0	1.2841	1150.8	.8690
122.0	1.3550	1142.0	.8757
123.0	1.4288	1133.0	.8826
124.0	1.5053	1123.9	.8897

TABLE 1–a (*cont'd*)

ARGON

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
125.0	1.5848	1114.6	.8971
126.0	1.6671	1105.2	.9048
127.0	1.7525	1095.5	.9128
128.0	1.8410	1085.6	.9211
129.0	1.9326	1075.5	.9298
130.0	2.0274	1065.2	.9388
131.0	2.1256	1054.6	.9483
132.0	2.2271	1043.7	.9582
133.0	2.3320	1032.4	.9686
134.0	2.4405	1020.8	.9796
135.0	2.5526	1008.9	.9912
136.0	2.6684	996.5	1.0035
137.0	2.7880	983.6	1.0167
138.0	2.9114	970.2	1.0307
139.0	3.0389	956.1	1.0459
140.0	3.1704	941.4	1.0622
141.0	3.3061	925.9	1.0801
142.0	3.4462	909.4	1.0996
143.0	3.5908	891.8	1.1213
144.0	3.7399	872.9	1.1456
145.0	3.8938	852.3	1.1733
146.0	4.0527	829.6	1.2054
147.0	4.2168	804.0	1.2437
148.0	4.3863	774.3	1.2915
149.0	4.5617	737.7	1.3557
150.0	4.7434	687.3	1.4550

TABLE 1–b ARGON (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.40	.60	.80	1.00	1.50	2.00	2.50	3.00	3.50	4.00
TEMP													
85.0	1407.8	1407.9	1408.2	1408.7	1409.3	1409.9	1410.5	1411.9	1413.3	1414.7	1416.1	1417.4	1418.8
85.5		1404.9	1405.1	1405.7	1406.3	1406.9	1407.5	1408.9	1410.3	1411.7	1413.1	1414.5	1415.9
86.0		1401.8	1402.1	1402.7	1403.3	1403.9	1404.4	1405.9	1407.3	1408.8	1410.2	1411.6	1413.0
86.5		1398.8	1399.1	1399.7	1400.2	1400.8	1401.4	1402.9	1404.3	1405.8	1407.2	1408.6	1410.0
87.0		1395.7	1396.0	1396.6	1397.2	1397.8	1398.4	1399.9	1401.3	1402.8	1404.2	1405.7	1407.1
87.5			1392.9	1393.5	1394.1	1394.7	1395.3	1396.8	1398.3	1399.8	1401.2	1402.7	1404.1
88.0			1389.8	1390.4	1391.1	1391.7	1392.3	1393.8	1395.3	1396.8	1398.3	1399.7	1401.2
88.5			1386.7	1387.4	1388.0	1388.6	1389.2	1390.7	1392.2	1393.8	1395.2	1396.7	1398.2
89.0			1383.6	1384.2	1384.9	1385.5	1386.1	1387.7	1389.2	1390.7	1392.2	1393.7	1395.2
89.5			1380.5	1381.1	1381.8	1382.4	1383.0	1384.6	1386.1	1387.7	1389.2	1390.7	1392.2
90.0			1377.3	1378.0	1378.6	1379.3	1379.9	1381.5	1383.1	1384.6	1386.1	1387.7	1389.2
90.5			1374.2	1374.8	1375.5	1376.1	1376.8	1378.4	1380.0	1381.5	1383.1	1384.6	1386.2
91.0			1371.0	1371.7	1372.3	1373.0	1373.6	1375.3	1376.9	1378.4	1380.0	1381.6	1383.1
91.5			1367.8	1368.5	1369.2	1369.8	1370.5	1372.1	1373.7	1375.3	1376.9	1378.5	1380.1
92.0			1364.6	1365.3	1366.0	1366.6	1367.3	1369.0	1370.6	1372.2	1373.8	1375.4	1377.0
92.5			1361.4	1362.1	1362.8	1363.5	1364.1	1365.8	1367.5	1369.1	1370.7	1372.4	1374.0
93.0			1358.2	1358.9	1359.6	1360.2	1360.9	1362.6	1364.3	1366.0	1367.6	1369.3	1370.9
93.5			1354.9	1355.6	1356.3	1357.0	1357.7	1359.4	1361.1	1362.8	1364.5	1366.2	1367.8
94.0			1351.7	1352.4	1353.1	1353.8	1354.5	1356.2	1358.0	1359.7	1361.4	1363.0	1364.7
94.5				1349.1	1349.8	1350.6	1351.3	1353.0	1354.8	1356.5	1358.2	1359.9	1361.6
95.0				1345.8	1346.6	1347.3	1348.0	1349.8	1351.6	1353.3	1355.0	1356.8	1358.4
95.5				1342.5	1343.3	1344.0	1344.7	1346.5	1348.3	1350.1	1351.9	1353.6	1355.3
96.0				1339.2	1340.0	1340.7	1341.5	1343.3	1345.1	1346.9	1348.7	1350.4	1352.2
96.5				1335.9	1336.7	1337.4	1338.2	1340.0	1341.8	1343.7	1345.5	1347.2	1349.0
97.0				1332.6	1333.3	1334.1	1334.8	1336.7	1338.6	1340.4	1342.2	1344.0	1345.8
97.5				1329.2	1330.0	1330.8	1331.5	1333.4	1335.3	1337.2	1339.0	1340.8	1342.6
98.0				1325.8	1326.6	1327.4	1328.2	1330.1	1332.0	1333.9	1335.8	1337.6	1339.4
98.5				1322.4	1323.2	1324.0	1324.8	1326.8	1328.7	1330.6	1332.5	1334.4	1336.2
99.0				1319.0	1319.8	1320.6	1321.4	1323.4	1325.4	1327.3	1329.2	1331.1	1333.0
99.5				1315.6	1316.4	1317.2	1318.0	1320.1	1322.0	1324.0	1325.9	1327.9	1329.8
100.0				1312.2	1313.0	1313.8	1314.6	1316.7	1318.7	1320.7	1322.6	1324.6	1326.5
100.5				1308.7	1309.5	1310.4	1311.2	1313.3	1315.3	1317.3	1319.3	1321.3	1323.2
101.0				1305.2	1306.1	1306.9	1307.8	1309.9	1311.9	1314.0	1316.0	1318.0	1320.0
101.5				1301.7	1302.6	1303.4	1304.3	1306.4	1308.5	1310.6	1312.6	1314.7	1316.7
102.0				1298.2	1299.1	1299.9	1300.8	1303.0	1305.1	1307.2	1309.3	1311.3	1313.4
102.5				1294.7	1295.5	1296.4	1297.3	1299.5	1301.7	1303.8	1305.9	1308.0	1310.0
103.0					1292.0	1292.9	1293.8	1296.0	1298.2	1300.4	1302.5	1304.6	1306.7
103.5					1288.4	1289.4	1290.3	1292.5	1294.7	1296.9	1299.1	1301.2	1303.3
104.0					1284.9	1285.8	1286.7	1289.0	1291.3	1293.5	1295.7	1297.8	1300.0
104.5					1281.2	1282.2	1283.1	1285.5	1287.7	1290.0	1292.2	1294.4	1296.6
105.0					1277.6	1278.6	1279.5	1281.9	1284.2	1286.5	1288.8	1291.0	1293.2
105.5					1274.0	1274.9	1275.9	1278.3	1280.7	1283.0	1285.3	1287.5	1289.8
106.0					1270.3	1271.3	1272.3	1274.7	1277.1	1279.5	1281.8	1284.1	1286.3
106.5					1266.6	1267.6	1268.6	1271.1	1273.5	1275.9	1278.3	1280.6	1282.9
107.0					1262.9	1263.9	1264.9	1267.4	1269.9	1272.4	1274.8	1277.1	1279.4
107.5					1259.2	1260.2	1261.2	1263.8	1266.3	1268.8	1271.2	1273.6	1276.0
108.0					1255.4	1256.4	1257.5	1260.1	1262.6	1265.2	1267.6	1270.1	1272.5
108.5						1252.7	1253.7	1256.4	1259.0	1261.5	1264.0	1266.5	1268.9
109.0						1248.9	1250.0	1252.6	1255.3	1257.9	1260.4	1262.9	1265.4
109.5						1245.0	1246.2	1248.9	1251.6	1254.2	1256.8	1259.3	1261.9
110.0						1241.2	1242.3	1245.1	1247.8	1250.5	1253.1	1255.7	1258.3
110.5						1237.3	1238.5	1241.3	1244.1	1246.8	1249.5	1252.1	1254.7
111.0						1233.4	1234.6	1237.5	1240.3	1243.1	1245.8	1248.4	1251.1
111.5						1229.5	1230.7	1233.6	1236.5	1239.3	1242.1	1244.8	1247.4
112.0						1225.5	1226.7	1229.7	1232.6	1235.5	1238.3	1241.1	1243.8
112.5						1221.5	1222.7	1225.8	1228.8	1231.7	1234.5	1237.4	1240.1
113.0							1218.7	1221.8	1224.9	1227.8	1230.8	1233.6	1236.4
113.5							1214.7	1217.9	1220.9	1224.0	1226.9	1229.8	1232.7
114.0							1210.6	1213.8	1217.0	1220.1	1223.1	1226.1	1228.9
114.5							1206.5	1209.8	1213.0	1216.2	1219.2	1222.2	1225.2
115.0							1202.4	1205.7	1209.0	1212.2	1215.3	1218.4	1221.4
115.5							1198.2	1201.6	1204.9	1208.2	1211.4	1214.5	1217.6

TABLE 1–b (*cont'd*) **ARGON** (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.40	.60	.80	1.00	1.50	2.00	2.50	3.00	3.50	4.00
TEMP													
116.0							1194.0	1197.5	1200.9	1204.2	1207.4	1210.6	1213.7
116.5							1189.7	1193.3	1196.8	1200.1	1203.5	1206.7	1209.9
117.0								1189.1	1192.6	1196.1	1199.4	1202.7	1206.0
117.5								1184.8	1188.4	1191.9	1195.4	1198.8	1202.0
118.0								1180.5	1184.2	1187.8	1191.3	1194.7	1198.1
118.5								1176.1	1179.9	1183.6	1187.2	1190.7	1194.1
119.0								1171.7	1175.6	1179.4	1183.0	1186.6	1190.1
119.5								1167.3	1171.3	1175.1	1178.8	1182.5	1186.0
120.0								1162.8	1166.9	1170.8	1174.6	1178.3	1182.0
120.5								1158.3	1162.4	1166.4	1170.4	1174.1	1177.8
121.0								1153.7	1157.9	1162.1	1166.0	1169.9	1173.7
121.5								1149.0	1153.4	1157.6	1161.7	1165.7	1169.5
122.0								1144.3	1148.8	1153.1	1157.3	1161.4	1165.3
122.5								1139.6	1144.2	1148.6	1152.9	1157.0	1161.0
123.0								1134.7	1139.5	1144.0	1148.4	1152.6	1156.7
123.5								1129.9	1134.7	1139.3	1143.8	1148.2	1152.4
124.0									1129.9	1134.6	1139.2	1143.7	1148.0
124.5									1125.0	1129.9	1134.6	1139.2	1143.6
125.0									1120.0	1125.1	1129.9	1134.6	1139.1
125.5									1115.0	1120.2	1125.2	1129.9	1134.5
126.0									1109.9	1115.2	1120.3	1125.2	1130.0
126.5									1104.7	1110.2	1115.5	1120.5	1125.3
127.0									1099.4	1105.1	1110.5	1115.7	1120.7
127.5									1094.1	1099.9	1105.5	1110.8	1115.9
128.0									1088.6	1094.7	1100.4	1105.9	1111.1
128.5									1083.1	1089.3	1095.2	1100.9	1106.3
129.0									1077.4	1083.9	1090.0	1095.8	1101.3
129.5									1071.7	1078.4	1084.7	1090.7	1096.4
130.0										1072.7	1079.2	1085.4	1091.3
130.5										1067.0	1073.7	1080.1	1086.2
131.0										1061.1	1068.1	1074.7	1081.0
131.5										1055.1	1062.4	1069.2	1075.7
132.0										1049.0	1056.6	1063.6	1070.3
132.5										1042.7	1050.6	1057.9	1064.8
133.0										1036.3	1044.5	1052.1	1059.3
133.5										1029.7	1038.3	1046.2	1053.6
134.0										1023.0	1031.9	1040.2	1047.8
134.5										1016.0	1025.4	1034.0	1041.9
135.0											1018.7	1027.7	1035.9
135.5											1011.8	1021.2	1029.8
136.0											1004.7	1014.5	1023.5
136.5											997.4	1007.7	1017.1
137.0											989.8	1000.7	1010.6
137.5											981.9	993.5	1003.8
138.0											973.8	986.0	996.9
138.5											965.3	978.3	989.8
139.0												970.3	982.5
139.5												962.0	974.9
140.0												953.3	967.0
140.5												944.2	958.9
141.0												934.6	950.5
141.5												924.5	941.6
142.0												913.7	932.4
142.5													922.7
143.0													912.4
143.5													901.4
144.0													889.7
144.5													876.9
145.0													862.9

TABLE 2–a

HELIUM

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
4.00	.0815	129.00	7.752
4.02	.0831	128.66	7.772
4.04	.0848	128.33	7.793
4.06	.0865	127.99	7.813
4.08	.0882	127.64	7.835
4.10	.0900	127.29	7.856
4.12	.0917	126.93	7.878
4.14	.0935	126.57	7.901
4.16	.0953	126.20	7.924
4.18	.0972	125.83	7.947
4.20	.0990	125.45	7.971
4.22	.1009	125.06	7.996
4.24	.1028	124.67	8.021
4.26	.1047	124.28	8.047
4.28	.1067	123.87	8.073
4.30	.1087	123.46	8.100
4.32	.1107	123.05	8.127
4.34	.1127	122.62	8.155
4.36	.1148	122.19	8.184
4.38	.1169	121.75	8.213
4.40	.1190	121.31	8.244
4.42	.1211	120.85	8.275
4.44	.1233	120.39	8.306
4.46	.1255	119.92	8.339
4.48	.1277	119.44	8.373
4.50	.1299	118.95	8.407
4.52	.1322	118.45	8.443
4.54	.1345	117.94	8.479
4.56	.1368	117.42	8.517
4.58	.1392	116.88	8.555
4.60	.1416	116.34	8.596
4.62	.1440	115.78	8.637
4.64	.1464	115.21	8.680
4.66	.1489	114.63	8.724
4.68	.1514	114.03	8.770
4.70	.1539	113.41	8.817
4.72	.1564	112.78	8.867
4.74	.1590	112.13	8.918
4.76	.1616	111.46	8.972
4.78	.1643	110.77	9.028

TABLE 2–a (*cont'd*)

HELIUM

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
4.80	.1670	110.05	9.086
4.82	.1697	109.32	9.148
4.84	.1724	108.55	9.212
4.86	.1752	107.76	9.280
4.88	.1780	106.93	9.352
4.90	.1808	106.07	9.427
4.92	.1837	105.17	9.508
4.94	.1866	104.23	9.594
4.96	.1895	103.24	9.686
4.98	.1925	102.19	9.785
5.00	.1954	101.08	9.893
5.02	.1985	99.90	10.010
5.04	.2015	98.63	10.139
5.06	.2046	97.25	10.282
5.08	.2077	95.75	10.444
5.10	.2109	94.08	10.629
5.12	.2141	92.20	10.846
5.14	.2173	90.01	11.109

TABLE 2–b HELIUM (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.085	.090	.100	.110	.120	.130	.140	.150	.160	.170	.180	.200	.220
TEMP													
4.00	129.2	129.5	130.0	130.5	131.0	131.5	131.9	132.4	132.8	133.2	133.7	134.5	135.2
4.01	129.0	129.3	129.8	130.3	130.8	131.3	131.8	132.2	132.6	133.1	133.5	134.3	135.1
4.02	128.8	129.0	129.6	130.1	130.6	131.1	131.6	132.0	132.5	132.9	133.3	134.1	134.9
4.03	128.6	128.8	129.4	129.9	130.4	130.9	131.4	131.8	132.3	132.7	133.2	134.0	134.8
4.04	128.3	128.6	129.2	129.7	130.2	130.7	131.2	131.7	132.1	132.6	133.0	133.8	134.6
4.05		128.4	129.0	129.5	130.0	130.5	131.0	131.5	131.9	132.4	132.8	133.6	134.4
4.06		128.2	128.8	129.3	129.8	130.3	130.8	131.3	131.8	132.2	132.6	133.5	134.3
4.07		128.0	128.5	129.1	129.6	130.1	130.6	131.1	131.6	132.0	132.5	133.3	134.1
4.08		127.7	128.3	128.9	129.4	129.9	130.4	130.9	131.4	131.9	132.3	133.1	134.0
4.09		127.5	128.1	128.7	129.2	129.7	130.2	130.7	131.2	131.7	132.1	133.0	133.8
4.10		127.3	127.9	128.5	129.0	129.5	130.0	130.5	131.0	131.5	131.9	132.8	133.6
4.11			127.7	128.2	128.8	129.3	129.8	130.3	130.8	131.3	131.8	132.6	133.5
4.12			127.4	128.0	128.6	129.1	129.6	130.2	130.6	131.1	131.6	132.5	133.3
4.13			127.2	127.8	128.4	128.9	129.4	130.0	130.4	130.9	131.4	132.3	133.1
4.14			127.0	127.6	128.1	128.7	129.2	129.8	130.3	130.7	131.2	132.1	133.0
4.15			126.7	127.3	127.9	128.5	129.0	129.6	130.1	130.5	131.0	131.9	132.8
4.16			126.5	127.1	127.7	128.3	128.8	129.3	129.9	130.4	130.8	131.7	132.6
4.17			126.3	126.9	127.5	128.1	128.6	129.1	129.7	130.2	130.6	131.6	132.4
4.18			126.0	126.6	127.3	127.8	128.4	128.9	129.5	130.0	130.4	131.4	132.3
4.19			125.8	126.4	127.0	127.6	128.2	128.7	129.2	129.8	130.3	131.2	132.1
4.20			125.5	126.2	126.8	127.4	128.0	128.5	129.0	129.6	130.1	131.0	131.9
4.21			125.3	125.9	126.6	127.2	127.7	128.3	128.8	129.4	129.9	130.8	131.7
4.22				125.7	126.3	126.9	127.5	128.1	128.6	129.1	129.7	130.6	131.5
4.23				125.4	126.1	126.7	127.3	127.9	128.4	128.9	129.5	130.4	131.4
4.24				125.2	125.8	126.5	127.1	127.6	128.2	128.7	129.2	130.2	131.2
4.25				124.9	125.6	126.2	126.8	127.4	128.0	128.5	129.0	130.0	131.0
4.26				124.6	125.3	126.0	126.6	127.2	127.8	128.3	128.8	129.8	130.8
4.27				124.4	125.1	125.7	126.4	127.0	127.5	128.1	128.6	129.6	130.6
4.28				124.1	124.8	125.5	126.1	126.7	127.3	127.9	128.4	129.4	130.4
4.29				123.8	124.5	125.2	125.9	126.5	127.1	127.6	128.2	129.2	130.2
4.30				123.6	124.3	125.0	125.6	126.2	126.8	127.4	128.0	129.0	130.0
4.31				123.3	124.0	124.7	125.4	126.0	126.6	127.2	127.8	128.8	129.8
4.32					123.7	124.4	125.1	125.8	126.4	127.0	127.5	128.6	129.6
4.33					123.5	124.2	124.9	125.5	126.1	126.7	127.3	128.4	129.4
4.34					123.2	123.9	124.6	125.3	125.9	126.5	127.1	128.2	129.2
4.35					122.9	123.6	124.3	125.0	125.7	126.3	126.9	128.0	129.0
4.36					122.6	123.4	124.1	124.8	125.4	126.0	126.6	127.8	128.8
4.37					122.3	123.1	123.8	124.5	125.2	125.8	126.4	127.5	128.6
4.38					122.0	122.8	123.5	124.2	124.9	125.5	126.2	127.3	128.4
4.39					121.7	122.5	123.3	124.0	124.6	125.3	125.9	127.1	128.2
4.40					121.4	122.2	123.0	123.7	124.4	125.0	125.7	126.9	128.0
4.41						121.9	122.7	123.4	124.1	124.8	125.4	126.6	127.7
4.42						121.6	122.4	123.1	123.9	124.5	125.2	126.4	127.5
4.43						121.3	122.1	122.9	123.6	124.3	124.9	126.2	127.3
4.44						121.0	121.8	122.6	123.3	124.0	124.7	125.9	127.1
4.45						120.7	121.5	122.3	123.0	123.7	124.4	125.7	126.8
4.46						120.3	121.2	122.0	122.7	123.5	124.2	125.4	126.6
4.47						120.0	120.9	121.7	122.5	123.2	123.9	125.2	126.4
4.48						119.7	120.5	121.4	122.2	122.9	123.6	124.9	126.1
4.49						119.3	120.2	121.1	121.9	122.6	123.3	124.7	125.9
4.50						119.0	119.9	120.8	121.6	122.3	123.1	124.4	125.7
4.51							119.5	120.4	121.3	122.1	122.8	124.2	125.4
4.52							119.2	120.1	121.0	121.8	122.5	123.9	125.2
4.53							118.9	119.8	120.6	121.5	122.2	123.6	124.9
4.54							118.5	119.4	120.3	121.1	121.9	123.4	124.7
4.55							118.1	119.1	120.0	120.8	121.6	123.1	124.4
4.56							117.7	118.7	119.7	120.5	121.3	122.8	124.2
4.57							117.4	118.4	119.3	120.2	121.0	122.5	123.9
4.58							117.0	118.0	119.0	119.9	120.7	122.3	123.6
4.59								117.6	118.6	119.5	120.4	122.0	123.4
4.60								117.3	118.3	119.2	120.1	121.7	123.1
4.61								116.9	117.9	118.9	119.7	121.4	122.8
4.62								116.5	117.5	118.5	119.4	121.1	122.6
4.63								116.1	117.1	118.1	119.1	120.8	122.3
4.64								115.6	116.8	117.8	118.7	120.5	122.0

TABLE 2–b (*cont'd*) **HELIUM** (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.085	.090	.100	.110	.120	.130	.140	.150	.160	.170	.180	.200	.220
TEMP													
4.65								115.2	116.4	117.4	118.4	120.1	121.7
4.66								114.8	116.0	117.0	118.0	119.8	121.4
4.67									115.5	116.6	117.7	119.5	121.1
4.68									115.1	116.2	117.3	119.2	120.8
4.69									114.7	115.8	116.9	118.8	120.5
4.70									114.2	115.4	116.5	118.5	120.2
4.71									113.7	115.0	116.1	118.1	119.9
4.72									113.3	114.6	115.7	117.8	119.5
4.73									112.8	114.1	115.3	117.4	119.2
4.74									112.3	113.6	114.9	117.0	118.9
4.75										113.2	114.4	116.6	118.5
4.76										112.7	114.0	116.3	118.2
4.77										112.2	113.5	115.9	117.8
4.78										111.7	113.1	115.5	117.5
4.79										111.1	112.6	115.0	117.1
4.80										110.6	112.1	114.6	116.7
4.81										110.0	111.6	114.2	116.4
4.82										109.4	111.0	113.7	116.0
4.83											110.5	113.3	115.6
4.84											109.9	112.8	115.2
4.85											109.3	112.3	114.8
4.86											108.7	111.8	114.3
4.87											108.0	111.3	113.9
4.88											107.4	110.8	113.5
4.89											106.6	110.3	113.0
4.90												109.7	112.6
4.91												109.1	112.1
4.92												108.5	111.6
4.93												107.9	111.1
4.94												107.2	110.6
4.95												106.5	110.0
4.96												105.8	109.5
4.97												105.0	108.9
4.98												104.2	108.3
4.99												103.4	107.7
5.00												102.5	107.0
5.01												101.5	106.4
5.02												100.4	105.7
5.03												99.3	104.9
5.04													104.2
5.05													103.4
5.06													102.5
5.07													101.6
5.08													100.6
5.09													99.6
5.10													98.4
5.11													97.2
5.12													95.7
5.13													94.1
5.14													92.2
5.15													89.8

TABLE 3–a

HYDROGEN

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
19.4	.0774	71.77	13.934
19.6	.0824	71.55	13.976
19.8	.0877	71.33	14.019
20.0	.0933	71.11	14.063
20.2	.0990	70.88	14.107
20.4	.1051	70.66	14.153
20.6	.1114	70.43	14.199
20.8	.1179	70.19	14.246
21.0	.1247	69.96	14.294
21.2	.1319	69.72	14.343
21.4	.1392	69.48	14.393
21.6	.1469	69.23	14.444
21.8	.1549	68.98	14.496
22.0	.1632	68.73	14.550
22.2	.1718	68.47	14.604
22.4	.1807	68.22	14.659
22.6	.1900	67.95	14.716
22.8	.1995	67.69	14.774
23.0	.2094	67.42	14.833
23.2	.2197	67.14	14.894
23.4	.2303	66.86	14.956
23.6	.2412	66.58	15.020
23.8	.2525	66.29	15.085
24.0	.2642	66.00	15.151
24.2	.2763	65.70	15.220
24.4	.2887	65.40	15.290
24.6	.3016	65.10	15.361
24.8	.3148	64.79	15.435
25.0	.3284	64.47	15.511
25.2	.3425	64.15	15.589
25.4	.3570	63.82	15.669
25.6	.3718	63.49	15.751
25.8	.3872	63.15	15.836
26.0	.4029	62.80	15.923
26.2	.4191	62.45	16.013
26.4	.4358	62.09	16.105
26.6	.4529	61.73	16.201
26.8	.4704	61.35	16.299

TABLE 3–a (*cont'd*)

HYDROGEN

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
27.0	.4885	60.97	16.402
27.2	.5070	60.58	16.507
27.4	.5260	60.18	16.617
27.6	.5456	59.77	16.730
27.8	.5656	59.35	16.848
28.0	.5861	58.93	16.971
28.2	.6072	58.49	17.098
28.4	.6287	58.03	17.231
28.6	.6509	57.57	17.370
28.8	.6735	57.09	17.516
29.0	.6967	56.60	17.669
29.2	.7205	56.09	17.829
29.4	.7449	55.56	17.998
29.6	.7698	55.02	18.176
29.8	.7953	54.45	18.365
30.0	.8214	53.86	18.566
30.2	.8482	53.25	18.780
30.4	.8755	52.60	19.010
30.6	.9035	51.93	19.256
30.8	.9322	51.22	19.522
31.0	.9615	50.48	19.811
31.2	.9915	49.68	20.127
31.4	1.0222	48.84	20.476
31.6	1.0535	47.92	20.867
31.8	1.0857	46.91	21.317
32.0	1.1185	45.74	21.863
32.2	1.1522	42.86	23.330
32.4	1.1866	39.99	25.007
32.6	1.2219	37.11	26.945
32.8	1.2581	34.24	29.209

TABLE 3–b HYDROGEN (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20
TEMP													
19.4	71.77	71.80	71.93	72.05	72.18	72.30	72.42	72.54	72.66	72.78	72.89	73.01	73.12
19.6		71.57	71.70	71.83	71.96	72.09	72.21	72.33	72.45	72.57	72.69	72.80	72.92
19.8		71.35	71.48	71.61	71.74	71.87	72.00	72.12	72.24	72.36	72.48	72.60	72.72
20.0		71.12	71.25	71.39	71.52	71.65	71.78	71.90	72.03	72.15	72.27	72.40	72.51
20.2		70.89	71.02	71.16	71.30	71.43	71.56	71.69	71.81	71.94	72.06	72.19	72.31
20.4			70.79	70.93	71.07	71.20	71.34	71.47	71.60	71.72	71.85	71.98	72.10
20.6			70.55	70.70	70.84	70.97	71.11	71.24	71.38	71.51	71.63	71.76	71.89
20.8			70.31	70.46	70.60	70.74	70.88	71.02	71.15	71.29	71.42	71.54	71.67
21.0			70.07	70.22	70.36	70.51	70.65	70.79	70.93	71.06	71.19	71.33	71.46
21.2			69.82	69.97	70.12	70.27	70.41	70.56	70.70	70.83	70.97	71.10	71.24
21.4			69.57	69.73	69.88	70.03	70.18	70.32	70.46	70.60	70.74	70.88	71.01
21.6			69.31	69.47	69.63	69.78	69.93	70.08	70.23	70.37	70.51	70.65	70.79
21.8			69.05	69.22	69.38	69.53	69.69	69.84	69.99	70.13	70.28	70.42	70.56
22.0			68.79	68.96	69.12	69.28	69.44	69.59	69.74	69.89	70.04	70.18	70.33
22.2			68.52	68.69	68.86	69.02	69.18	69.34	69.50	69.65	69.80	69.95	70.09
22.4			68.25	68.42	68.59	68.76	68.93	69.09	69.25	69.40	69.56	69.71	69.85
22.6			67.97	68.15	68.32	68.50	68.66	68.83	68.99	69.15	69.31	69.46	69.61
22.8			67.68	67.87	68.05	68.23	68.40	68.57	68.73	68.90	69.06	69.21	69.37
23.0				67.58	67.77	67.95	68.13	68.30	68.47	68.64	68.80	68.96	69.12
23.2				67.29	67.48	67.67	67.85	68.03	68.21	68.38	68.54	68.71	68.87
23.4				67.00	67.19	67.39	67.57	67.76	67.93	68.11	68.28	68.45	68.61
23.6				66.70	66.90	67.10	67.29	67.48	67.66	67.84	68.01	68.19	68.35
23.8				66.39	66.60	66.80	67.00	67.19	67.38	67.56	67.74	67.92	68.09
24.0				66.08	66.29	66.50	66.70	66.90	67.09	67.28	67.47	67.65	67.82
24.2				65.76	65.98	66.19	66.40	66.61	66.80	67.00	67.19	67.37	67.55
24.4				65.43	65.66	65.88	66.09	66.30	66.51	66.71	66.90	67.09	67.28
24.6					65.33	65.56	65.78	66.00	66.21	66.41	66.61	66-81	67.00
24.8					64.99	65.23	65.46	65.68	65.90	66.11	66.32	66.52	66.71
25.0					64.65	64.90	65.13	65.36	65.59	65.80	66.01	66.22	66.42
25.2					64.30	64.55	64.80	65.04	65.27	65.49	65.71	65.92	66.12
25.4					63.94	64.20	64.46	64.70	64.94	65.17	65.40	65.61	65.82
25.6					63.57	63.84	64.11	64.36	64.61	64.85	65.08	65.30	65.52
25.8					63.19	63.47	63.75	64.01	64.27	64.51	64.75	64.98	65.21
26.0						63.09	63.38	63.65	63.92	64.17	64.42	64.66	64.89
26.2						62.70	63.00	63.29	63.56	63.83	64.08	64.33	64.57
26.4						62.30	62.61	62.91	63.20	63.47	63.73	63.99	64.23
26.6						61.88	62.21	62.52	62.82	63.10	63.38	63.64	63.90
26.8						61.45	61.80	62.12	62.43	62.73	63.02	63.29	63.55
27.0						61.01	61.37	61.71	62.04	62.35	62.64	62.93	63.20
27.2							60.93	61.29	61.63	61.95	62.26	62.56	62.84
27.4							60.47	60.85	61.21	61.55	61.87	62.17	62.47
27.6							60.00	60.40	60.77	61.13	61.46	61.78	62.09
27.8							59.50	59.93	60.32	60.70	61.05	61.38	61.70
28.0							58.99	59.44	59.86	60.25	60.62	60.97	61.30
28.2								58.93	59.37	59.79	60.18	60.55	60.89
28.4								58.39	58.87	59.31	59.72	60.11	60.47
28.6								57.83	58.34	58.81	59.25	59.65	60.04
28.8								57.24	57.79	58.29	58.75	59.19	59.59
29.0								56.61	57.21	57.75	58.24	58.70	59.12
29.2									56.59	57.18	57.71	58.19	58.64
29.4									55.94	56.58	57.15	57.67	58.15
29.6									55.24	55.94	56.56	57.12	57.63
29.8									54.48	55.26	55.94	56.54	57.09
30.0										54.53	55.28	55.93	56.52
30.2										53.73	54.57	55.29	55.93
30.4										52.86	53.81	54.60	55.30
30.6											52.98	53.87	54.64
30.8											52.06	53.08	53.93
31.0											51.02	52.21	53.17
31.2											49.81	51.25	52.35
31.4												50.15	51.44
31.6												48.86	50.44
31.8												47.25	49.29
32.0													47.93

TABLE 4–a

NITROGEN

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
75.0	.0760	819.3	1.221
76.0	.0860	814.8	1.227
77.0	.0971	810.3	1.234
78.0	.1091	805.7	1.241
79.0	.1223	801.1	1.248
80.0	.1367	796.4	1.256
81.0	.1523	791.6	1.263
82.0	.1692	786.8	1.271
83.0	.1875	782.0	1.279
84.0	.2072	777.0	1.287
85.0	.2284	772.0	1.295
86.0	.2512	767.0	1.304
87.0	.2757	761.9	1.313
88.0	.3019	756.7	1.322
89.0	.3299	751.4	1.331
90.0	.3597	746.1	1.340
91.0	.3915	740.7	1.350
92.0	.4254	735.3	1.360
93.0	.4613	729.7	1.370
94.0	.4994	724.1	1.381
95.0	.5397	718.4	1.392
96.0	.5823	712.6	1.403
97.0	.6274	706.8	1.415
98.0	.6749	700.8	1.427
99.0	.7250	694.8	1.439
100.0	.7777	688.6	1.452
101.0	.8331	682.4	1.465
102.0	.8913	676.0	1.479
103.0	.9524	669.6	1.493
104.0	1.0164	663.0	1.508
105.0	1.0835	656.2	1.524
106.0	1.1537	649.4	1.540
107.0	1.2270	642.3	1.557
108.0	1.3037	635.1	1.575
109.0	1.3837	627.7	1.593
110.0	1.4672	620.1	1.613
111.0	1.5543	612.3	1.633
112.0	1.6450	604.3	1.655
113.0	1.7394	595.9	1.678
114.0	1.8376	587.3	1.703

TABLE 4–a (*cont'd*)

NITROGEN

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
115.0	1.9398	578.2	1.729
116.0	2.0460	568.8	1.758
117.0	2.1564	558.9	1.789
118.0	2.2709	548.4	1.823
119.0	2.3899	537.2	1.861
120.0	2.5133	525.2	1.904
121.0	2.6414	512.0	1.953
122.0	2.7742	497.2	2.011
123.0	2.9120	480.1	2.083
124.0	3.0550	458.9	2.179
125.0	3.2034	429.5	2.328
126.0	3.3578	442.6	2.259

TABLE 4–b NITROGEN (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.40	.60	.80	1.00	1.25	1.50	1.75	2.00	2.50	3.00
TEMP													
75.0	819.3	819.3	819.6	820.0	820.4	820.8	821.2	821.8	822.3	822.8	823.3	824.3	825.3
75.5		817.1	817.3	817.8	818.2	818.6	819.0	819.6	820.1	820.6	821.1	822.2	823.2
76.0		814.8	815.1	815.5	815.9	816.4	816.8	817.4	817.9	818.4	819.0	820.0	821.1
76.5		812.6	812.8	813.2	813.7	814.1	814.6	815.1	815.7	816.2	816.8	817.9	818.9
77.0		810.3	810.5	811.0	811.4	811.9	812.3	812.9	813.5	814.0	814.6	815.7	816.8
77.5			808.2	808.7	809.2	809.6	810.1	810.7	811.2	811.8	812.4	813.5	814.6
78.0			805.9	806.4	806.9	807.3	807.8	808.4	809.0	809.6	810.1	811.3	812.4
78.5			803.6	804.1	804.5	805.0	805.5	806.1	806.7	807.3	807.9	809.1	810.2
79.0			801.2	801.7	802.2	802.7	803.2	803.8	804.4	805.0	805.6	806.8	808.0
79.5			798.9	799.4	799.9	800.4	800.9	801.5	802.1	802.8	803.4	804.6	805.8
80.0			796.5	797.0	797.5	798.1	798.6	799.2	799.8	800.5	801.1	802.3	803.6
80.5			794.1	794.6	795.2	795.7	796.2	796.9	797.5	798.2	798.8	800.1	801.3
81.0			791.7	792.2	792.8	793.3	793.9	794.5	795.2	795.8	796.5	797.8	799.1
81.5			789.3	789.8	790.4	790.9	791.5	792.2	792.8	793.5	794.2	795.5	796.8
82.0			786.8	787.4	788.0	788.5	789.1	789.8	790.5	791.2	791.8	793.2	794.5
82.5			784.4	785.0	785.5	786.1	786.7	787.4	788.1	788.8	789.5	790.9	792.2
83.0			781.9	782.5	783.1	783.7	784.3	785.0	785.7	786.4	787.1	788.5	789.9
83.5			779.4	780.0	780.6	781.2	781.8	782.6	783.3	784.0	784.8	786.2	787.6
84.0				777.5	778.1	778.8	779.4	780.1	780.9	781.6	782.4	783.8	785.3
84.5				775.0	775.7	776.3	776.9	777.7	778.4	779.2	780.0	781.4	782.9
85.0				772.5	773.1	773.8	774.4	775.2	776.0	776.8	777.5	779.1	780.5
85.5				770.0	770.6	771.3	771.9	772.7	773.5	774.3	775.1	776.6	778.2
86.0				767.4	768.1	768.7	769.4	770.2	771.0	771.8	772.6	774.2	775.8
86.5				764.8	765.5	766.2	766.9	767.7	768.5	769.4	770.2	771.8	773.4
87.0				762.2	762.9	763.6	764.3	765.2	766.0	766.9	767.7	769.3	771.0
87.5				759.6	760.3	761.0	761.7	762.6	763.5	764.4	765.2	766.9	768.5
88.0				757.0	757.7	758.4	759.2	760.1	760.9	761.8	762.7	764.4	766.1
88.5				754.3	755.1	755.8	756.6	757.5	758.4	759.3	760.2	761.9	763.6
89.0				751.6	752.4	753.2	753.9	754.9	755.8	756.7	757.6	759.4	761.1
89.5				748.9	749.7	750.5	751.3	752.2	753.2	754.1	755.0	756.9	758.6
90.0				746.2	747.0	747.8	748.6	749.6	750.6	751.5	752.5	754.3	756.1
90.5				743.5	744.3	745.1	745.9	746.9	747.9	748.9	749.9	751.8	753.6
91.0				740.7	741.6	742.4	743.2	744.2	745.3	746.3	747.2	749.2	751.1
91.5					738.8	739.7	740.5	741.5	742.6	743.6	744.6	746.6	748.5
92.0					736.0	736.9	737.8	738.8	739.9	740.9	741.9	744.0	745.9
92.5					733.2	734.1	735.0	736.1	737.2	738.2	739.3	741.3	743.4
93.0					730.4	731.3	732.2	733.3	734.4	735.5	736.6	738.7	740.7
93.5					727.5	728.4	729.4	730.5	731.6	732.8	733.9	736.0	738.1
94.0					724.6	725.6	726.5	727.7	728.9	730.0	731.1	733.3	735.5
94.5					721.7	722.7	723.7	724.9	726.0	727.2	728.4	730.6	732.8
95.0					718.8	719.8	720.8	722.0	723.2	724.4	725.6	727.9	730.1
95.5					715.8	716.8	717.8	719.1	720.3	721.6	722.8	725.1	727.4
96.0					712.8	713.8	714.9	716.2	717.5	718.7	719.9	722.4	724.7
96.5						710.8	711.9	713.2	714.5	715.8	717.1	719.6	721.9
97.0						707.8	708.9	710.3	711.6	712.9	714.2	716.7	719.2
97.5						704.7	705.9	707.3	708.6	710.0	711.3	713.9	716.4
98.0						701.6	702.8	704.2	705.6	707.0	708.4	711.0	713.6
98.5						698.5	699.7	701.2	702.6	704.0	705.4	708.1	710.7
99.0						695.3	696.5	698.1	699.5	701.0	702.4	705.2	707.9
99.5						692.1	693.4	694.9	696.4	697.9	699.4	702.2	705.0
100.0						688.8	690.2	691.7	693.3	694.8	696.3	699.3	702.1
100.5							686.9	688.5	690.1	691.7	693.3	696.3	699.1
101.0							683.6	685.3	686.9	688.6	690.1	693.2	696.2
101.5							680.3	682.0	683.7	685.4	687.0	690.2	693.2
102.0							676.9	678.7	680.4	682.1	683.8	687.1	690.2
102.5							673.5	675.3	677.1	678.9	680.6	683.9	687.1
103.0							670.0	671.9	673.7	675.6	677.3	680.8	684.0
103.5							666.4	668.4	670.3	672.2	674.0	677.6	680.9
104.0								664.9	666.9	668.8	670.7	674.3	677.8
104.5								661.3	663.4	665.4	667.3	671.0	674.6
105.0								657.7	659.8	661.9	663.9	667.7	671.4
105.5								654.0	656.2	658.3	660.4	664.3	668.1

TABLE 4–b (*cont'd*) **NITROGEN** (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.40	.60	.80	1.00	1.25	1.50	1.75	2.00	2.50	3.00
TEMP													
106.0								650.3	652.5	654.7	656.9	660.9	664.8
106.5								646.4	648.8	651.1	653.3	657.5	661.5
107.0								642.5	645.0	647.3	649.6	654.0	658.1
107.5									641.1	643.6	645.9	650.4	654.7
108.0									637.2	639.7	642.2	646.8	651.2
108.5									633.1	635.8	638.3	643.2	647.7
109.0									629.0	631.8	634.4	639.4	644.1
109.5									624.8	627.7	630.4	635.6	640.5
110.0									620.5	623.5	626.4	631.8	636.8
110.5										619.2	622.2	627.9	633.1
111.0										614.8	618.0	623.8	629.2
111.5										610.3	613.6	619.8	625.4
112.0										605.7	609.2	615.6	621.4
112.5										600.9	604.6	611.3	617.4
113.0										596.0	599.9	606.9	613.3
113.5											595.0	602.4	609.1
114.0											590.0	597.8	604.8
114.5											584.8	593.1	600.4
115.0											579.4	588.2	595.9
115.5											573.7	583.2	591.3
116.0												577.9	586.5
116.5												572.5	581.6
117.0												566.8	576.6
117.5												560.8	571.3
118.0												554.5	565.9
118.5												547.9	560.2
119.0												540.8	554.2
119.5												533.1	548.0
120.0													541.4
120.5													534.3
121.0													526.7
121.5													518.5
122.0													509.4
122.5													499.0
123.0													486.9

TABLE 5–a

OXYGEN

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
88.0	.0801	1151.9	.8682
89.0	.0893	1147.0	.8719
90.0	.0993	1142.0	.8756
91.0	.1102	1137.0	.8795
92.0	.1219	1132.0	.8834
93.0	.1346	1127.0	.8873
94.0	.1483	1121.9	.8913
95.0	.1631	1116.8	.8954
96.0	.1789	1111.7	.8995
97.0	.1958	1106.5	.9037
98.0	.2139	1101.3	.9080
99.0	.2333	1096.1	.9123
100.0	.2540	1090.8	.9167
101.0	.2760	1085.5	.9212
102.0	.2994	1080.1	.9258
103.0	.3243	1074.7	.9305
104.0	.3506	1069.3	.9352
105.0	.3785	1063.8	.9401
106.0	.4081	1058.2	.9450
107.0	.4392	1052.6	.9500
108.0	.4722	1046.9	.9552
109.0	.5069	1041.2	.9604
110.0	.5434	1035.4	.9658
111.0	.5818	1029.6	.9712
112.0	.6222	1023.7	.9768
113.0	.6646	1017.7	.9826
114.0	.7090	1011.7	.9884
115.0	.7556	1005.6	.9944
116.0	.8043	999.4	1.0006
117.0	.8553	993.2	1.0069
118.0	.9085	986.8	1.0134
119.0	.9642	980.4	1.0200
120.0	1.0222	973.9	1.0268
121.0	1.0827	967.2	1.0339
122.0	1.1458	960.5	1.0411
123.0	1.2114	953.7	1.0485
124.0	1.2797	946.8	1.0562

TABLE 5–a (*cont'd*)

OXYGEN

Temp. K	Vapor pressure MPa	Density kg/m^3	Volume / mass unit dm^3/kg
125.0	1.3507	939.7	1.0642
126.0	1.4245	932.5	1.0723
127.0	1.5012	925.2	1.0808
128.0	1.5807	917.8	1.0896
129.0	1.6633	910.2	1.0987
130.0	1.7488	902.4	1.1081
131.0	1.8375	894.5	1.1179
132.0	1.9294	886.4	1.1282
133.0	2.0245	878.1	1.1388
134.0	2.1229	869.6	1.1500
135.0	2.2248	860.9	1.1616
136.0	2.3301	851.9	1.1738
137.0	2.4389	842.7	1.1867
138.0	2.5514	833.2	1.2002
139.0	2.6676	823.3	1.2146
140.0	2.7875	813.2	1.2298
141.0	2.9114	802.6	1.2459
142.0	3.0392	791.6	1.2632
143.0	3.1711	780.2	1.2818
144.0	3.3072	768.2	1.3018
145.0	3.4476	755.5	1.3236
146.0	3.5924	742.2	1.3474
147.0	3.7417	727.9	1.3738
148.0	3.8958	712.6	1.4033
149.0	4.0547	695.9	1.4369
150.0	4.2186	677.5	1.4760
151.0	4.3878	656.6	1.5230
152.0	4.5625	631.8	1.5828
153.0	4.7432	599.9	1.6670
154.0	4.9305	550.3	1.8173

TABLE 5–b OXYGEN (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.40	.60	.80	1.00	1.50	2.00	2.50	3.00	3.50	4.00
TEMP													
88.0		1151.9	1152.1	1152.5	1152.9	1153.4	1153.8	1154.8	1155.9	1156.9	1157.9	1158.9	1160.0
88.5		1149.4	1149.6	1150.1	1150.5	1150.9	1151.3	1152.4	1153.4	1154.5	1155.5	1156.6	1157.6
89.0		1146.9	1147.2	1147.6	1148.0	1148.5	1148.9	1150.0	1151.0	1152.1	1153.1	1154.2	1155.2
89.5		1144.5	1144.7	1145.1	1145.5	1146.0	1146.4	1147.5	1148.6	1149.6	1150.7	1151.8	1152.8
90.0		1142.0	1142.2	1142.6	1143.1	1143.5	1144.0	1145.0	1146.1	1147.2	1148.3	1149.4	1150.4
90.5			1139.7	1140.1	1140.6	1141.0	1141.5	1142.6	1143.7	1144.8	1145.9	1146.9	1148.0
91.0			1137.2	1137.6	1138.1	1138.5	1139.0	1140.1	1141.2	1142.3	1143.4	1144.5	1145.6
91.5			1134.7	1135.1	1135.6	1136.1	1136.5	1137.6	1138.8	1139.9	1141.0	1142.1	1143.2
92.0			1132.2	1132.6	1133.1	1133.5	1134.0	1135.2	1136.3	1137.4	1138.5	1139.7	1140.8
92.5			1129.6	1130.1	1130.6	1131.0	1131.5	1132.7	1133.8	1135.0	1136.1	1137.2	1138.3
93.0			1127.1	1127.6	1128.0	1128.5	1129.0	1130.2	1131.3	1132.5	1133.6	1134.8	1135.9
93.5			1124.5	1125.0	1125.5	1126.0	1126.5	1127.7	1128.8	1130.0	1131.2	1132.3	1133.5
94.0			1122.0	1122.5	1123.0	1123.5	1123.9	1125.1	1126.3	1127.5	1128.7	1129.9	1131.0
94.5			1119.4	1119.9	1120.4	1120.9	1121.4	1122.6	1123.8	1125.0	1126.2	1127.4	1128.6
95.0			1116.9	1117.4	1117.9	1118.4	1118.9	1120.1	1121.3	1122.5	1123.7	1124.9	1126.1
95.5			1114.3	1114.8	1115.3	1115.8	1116.3	1117.5	1118.8	1120.0	1121.2	1122.4	1123.6
96.0			1111.7	1112.2	1112.7	1113.2	1113.7	1115.0	1116.3	1117.5	1118.7	1119.9	1121.2
96.5			1109.1	1109.6	1110.1	1110.6	1111.2	1112.4	1113.7	1115.0	1116.2	1117.4	1118.7
97.0			1106.5	1107.0	1107.5	1108.1	1108.6	1109.9	1111.2	1112.4	1113.7	1114.9	1116.2
97.5				1104.4	1104.9	1105.5	1106.0	1107.3	1108.6	1109.9	1111.2	1112.4	1113.7
98.0				1101.8	1102.3	1102.8	1103.4	1104.7	1106.0	1107.3	1108.6	1109.9	1111.2
98.5				1099.1	1099.7	1100.2	1100.8	1102.1	1103.4	1104.8	1106.1	1107.4	1108.7
99.0				1096.5	1097.0	1097.6	1098.1	1099.5	1100.9	1102.2	1103.5	1104.8	1106.1
99.5				1093.8	1094.4	1094.9	1095.5	1096.9	1098.3	1099.6	1101.0	1102.3	1103.6
100.0				1091.2	1091.7	1092.3	1092.9	1094.3	1095.6	1097.0	1098.4	1099.7	1101.1
100.5				1088.5	1089.1	1089.6	1090.2	1091.6	1093.0	1094.4	1095.8	1097.2	1098.5
101.0				1085.8	1086.4	1086.9	1087.5	1089.0	1090.4	1091.8	1093.2	1094.6	1095.9
101.5				1083.1	1083.7	1084.3	1084.8	1086.3	1087.8	1089.2	1090.6	1092.0	1093.4
102.0				1080.4	1081.0	1081.6	1082.2	1083.6	1085.1	1086.5	1088.0	1089.4	1090.8
102.5				1077.6	1078.2	1078.8	1079.5	1081.0	1082.4	1083.9	1085.4	1086.8	1088.2
103.0				1074.9	1075.5	1076.1	1076.7	1078.3	1079.8	1081.2	1082.7	1084.2	1085.6
103.5				1072.1	1072.8	1073.4	1074.0	1075.5	1077.1	1078.6	1080.1	1081.5	1083.0
104.0				1069.4	1070.0	1070.6	1071.3	1072.8	1074.4	1075.9	1077.4	1078.9	1080.4
104.5				1066.6	1067.2	1067.9	1068.5	1070.1	1071.7	1073.2	1074.7	1076.3	1077.7
105.0				1063.8	1064.4	1065.1	1065.7	1067.3	1068.9	1070.5	1072.1	1073.6	1075.1
105.5				1061.0	1061.6	1062.3	1062.9	1064.6	1066.2	1067.8	1069.4	1070.9	1072.5
106.0					1058.8	1059.5	1060.1	1061.8	1063.4	1065.1	1066.7	1068.2	1069.8
106.5					1056.0	1056.6	1057.3	1059.0	1060.7	1062.3	1063.9	1065.5	1067.1
107.0					1053.1	1053.8	1054.5	1056.2	1057.9	1059.6	1061.2	1062.8	1064.4
107.5					1050.2	1051.0	1051.7	1053.4	1055.1	1056.8	1058.5	1060.1	1061.7
108.0					1047.4	1048.1	1048.8	1050.6	1052.3	1054.0	1055.7	1057.4	1059.0
108.5					1044.5	1045.2	1045.9	1047.7	1049.5	1051.2	1052.9	1054.6	1056.3
109.0					1041.5	1042.3	1043.0	1044.8	1046.6	1048.4	1050.1	1051.9	1053.6
109.5					1038.6	1039.4	1040.1	1042.0	1043.8	1045.6	1047.3	1049.1	1050.8
110.0					1035.6	1036.4	1037.2	1039.0	1040.9	1042.7	1044.5	1046.3	1048.0
110.5					1032.7	1033.4	1034.2	1036.1	1038.0	1039.9	1041.7	1043.5	1045.3
111.0					1029.7	1030.5	1031.3	1033.2	1035.1	1037.0	1038.8	1040.7	1042.5
111.5						1027.5	1028.3	1030.2	1032.2	1034.1	1036.0	1037.8	1039.7
112.0						1024.4	1025.3	1027.3	1029.2	1031.2	1033.1	1035.0	1036.8
112.5						1021.4	1022.2	1024.3	1026.3	1028.3	1030.2	1032.1	1034.0
113.0						1018.3	1019.2	1021.3	1023.3	1025.3	1027.3	1029.2	1031.1
113.5						1015.2	1016.1	1018.2	1020.3	1022.3	1024.3	1026.3	1028.3
114.0						1012.1	1013.0	1015.2	1017.3	1019.4	1021.4	1023.4	1025.4
114.5						1009.0	1009.9	1012.1	1014.2	1016.3	1018.4	1020.5	1022.5
115.0						1005.8	1006.7	1009.0	1011.2	1013.3	1015.4	1017.5	1019.6
115.5						1002.6	1003.6	1005.9	1008.1	1010.3	1012.4	1014.5	1016.6
116.0							1000.4	1002.7	1005.0	1007.2	1009.4	1011.5	1013.7
116.5							997.2	999.5	1001.8	1004.1	1006.3	1008.5	1010.7
117.0							993.9	996.3	998.7	1001.0	1003.3	1005.5	1007.7
117.5							990.6	993.1	995.5	997.9	1000.2	1002.4	1004.7
118.0							987.3	989.8	992.3	994.7	997.1	999.4	1001.6
118.5							984.0	986.6	989.1	991.5	993.9	996.3	998.6
119.0							980.6	983.3	985.8	988.3	990.7	993.1	995.5
119.5							977.2	979.9	982.5	985.1	987.6	990.0	992.4

TABLE 5–b (*cont'd*) **OXYGEN** (Temperature: K Pressure: MPa Density: kg/m^3)

PRES	.08	.10	.20	.40	.60	.80	1.00	1.50	2.00	2.50	3.00	3.50	4.00
TEMP													
120.0								976.5	979.2	981.8	984.3	986.8	989.3
120.5								973.1	975.9	978.5	981.1	983.6	986.1
121.0								969.7	972.5	975.2	977.8	980.4	982.9
121.5								966.2	969.1	971.8	974.5	977.2	979.7
122.0								962.7	965.6	968.4	971.2	973.9	976.5
122.5								959.2	962.1	965.0	967.8	970.6	973.3
123.0								955.6	958.6	961.6	964.4	967.2	970.0
123.5								951.9	955.1	958.1	961.0	963.9	966.7
124.0								948.3	951.5	954.6	957.6	960.5	963.3
124.5								944.6	947.8	951.0	954.1	957.1	960.0
125.0								940.8	944.2	947.4	950.6	953.6	956.6
125.5								937.0	940.4	943.8	947.0	950.1	953.1
126.0								933.1	936.7	940.1	943.4	946.6	949.7
126.5								929.2	932.9	936.4	939.7	943.0	946.2
127.0									929.0	932.6	936.1	939.4	942.7
127.5									925.1	928.8	932.3	935.8	939.1
128.0									921.1	924.9	928.6	932.1	935.5
128.5									917.1	921.0	924.7	928.4	931.8
129.0									913.0	917.0	920.9	924.6	928.2
129.5									908.9	913.0	917.0	920.8	924.4
130.0									904.7	908.9	913.0	916.9	920.7
130.5									900.4	904.8	909.0	913.0	916.8
131.0									896.0	900.6	904.9	909.0	913.0
131.5									891.6	896.3	900.7	905.0	909.1
132.0									887.1	891.9	896.5	900.9	905.1
132.5									882.5	887.5	892.3	896.8	901.1
133.0										883.0	887.9	892.6	897.0
133.5										878.4	883.5	888.3	892.9
134.0										873.8	879.0	884.0	888.7
134.5										869.0	874.4	879.6	884.4
135.0										864.1	869.8	875.1	880.1
135.5										859.1	865.0	870.5	875.7
136.0										854.0	860.2	865.9	871.2
136.5										848.8	855.2	861.1	866.7
137.0										843.5	850.1	856.3	862.1
137.5										838.0	844.9	851.4	857.3
138.0											839.6	846.3	852.5
138.5											834.1	841.2	847.6
139.0											828.5	835.9	842.6
139.5											822.8	830.4	837.5
140.0											816.8	824.9	832.2
140.5											810.6	819.2	826.9
141.0											804.2	813.3	821.4
141.5											797.6	807.2	815.7
142.0												800.9	809.9
142.5												794.4	803.9
143.0												787.6	797.7
143.5												780.5	791.3
144.0												773.1	784.6
144.5												765.3	777.7
145.0												757.1	770.5
145.5													763.0
146.0													755.0
146.5													746.6
147.0													737.6
147.5													727.9
148.0													717.4

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INTERNATIONAL
RECOMMENDATION

OIML R 81
Annex D

Edition 2006 (E)

Dynamic measuring devices and systems for cryogenic liquids

Annex D: Test Report Format

Dispositifs et systèmes de mesure dynamique des liquides cryogéniques

Annexe D: Format du rapport d'essai

OIML R 81 Annex D Edition 2006 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Contents

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 main categories of OIML publications are:

- **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. OIML Member States shall implement these Recommendations to the greatest possible extent;
- **International Documents (OIML D),** which are informative in nature and which are intended to harmonize and improve work in the field of legal metrology;
- **International Guides (OIML G),** which are also informative in nature and which are intended to give guidelines for the application of certain requirements to legal metrology; and
- **International Basic Publications (OIML B),** which define the operating rules of the various OIML structures and systems.

OIML Draft Recommendations, Documents and Guides are developed by Technical Committees or Subcommittees which comprise representatives from the Member States. Certain international and regional institutions also participate on a consultation basis. Cooperative agreements have been established between the OIML and certain institutions, such as ISO and the IEC, with the objective of avoiding contradictory requirements. Consequently, manufacturers and users of measuring instruments, test laboratories, etc. may simultaneously apply OIML publications and those of other institutions.

International Recommendations, Documents, Guides and Basic Publications are published in English (E) and translated into French (F) and are subject to periodic revision.

Additionally, the OIML publishes or participates in the publication of **Vocabularies (OIML V)** and periodically commissions legal metrology experts to write **Expert Reports (OIML E)**. Expert Reports are intended to provide information and advice, and are written solely from the viewpoint of their author, without the involvement of a Technical Committee or Subcommittee, nor that of the CIML. Thus, they do not necessarily represent the views of the OIML.

This publication - reference OIML R 81 Annex D, Edition 2006 (E) - was developed by the OIML Technical Subcommittee TC 8/SC 6 *Measurement of cryogenic liquids*. It was approved for final publication by the International Committee of Legal Metrology in 1999.

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Bureau International de Métrologie Légale
11, rue Turgot - 75009 Paris - France
Telephone: 33 (0)1 48 78 12 82
Fax: 33 (0)1 42 82 17 27
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Internet: www.oiml.org

Dynamic measuring devices and systems for cryogenic fluids
Annex D: Test Report Format

Introduction

This Annex is **informative** with regard to the implementation of OIML Recommendation R 81 in national regulations; however, use of the Test Report Format is **mandatory** for application of the Recommendation within the OIML Certificate System.

Test procedures are included in Annex A and Annex B of OIML R 81.

Possible situations that may occur in testing dynamic measuring systems:

Meter	Measurement transducer	Calculator (including the indicating device)	Remarks
Included	Included	Included	During the test the reference value (also called "true value") is provided by the reference (or working) standard (see 3.3 in R 81); the gravimetric method is recommended (see A.1 in R 81); other suitable methods may be used provided that the requirements of A.1.1 in R 81 are met (see A.1 in R 81).
Not included	Included	Not included	The measurement transducer may be tested alone provided that the computing and indicating devices have been subject to separate pattern (type) approvals (see 15.1.5.1, fourth paragraph in R 81); if applicable, the correction algorithm shall be applied to the output signal of the transducer to determine its errors (see 15.1.5.1, fourth paragraph in R 81); if applicable, the pulser is part of the transducer (see 3.6 in R 81) but may be tested together with the calculator (see third row below). See also the remark above in the first sentence.
Not included	Not included	Included	Tests are conducted by simulating the different inputs (see 15.1.6 in R 81). The signal generated by the measurement transducer should be simulated (for example by an impulse generator), generating a preset amount of pulses or by the pulser of the transducer which should be driven by a stepper motor; in the latter case the stepper motor should be driven by an impulse generator, generating a preset amount of pulses. When simulation of the transducer is not possible (for example in case of a Coriolis meter) other solutions may be acceptable.

Explanatory note to the use of the Test Report Format

General information

Numbers in brackets after the title on the test forms refer to the corresponding clause/subclause of OIML R 81.

Each of the following test forms contains four tables. **Select only one of the four tables for test results** (even when they are spread over two pages from D.13 to D.17).

Information on gravimetric test tables

Three tables accommodate the measurement results indicated in terms of:

1. Mass,
2. Liquid volume at the normal boiling point (NBP), or
3. Gas equivalent of a liquid volume at base conditions.

The reference value used in the tables is provided by the reference (or working) standard (See 3.3 in R 81) and shall be greater than or equal to five times the minimum measured quantity (A.1.2.1 and 6.5 in R 81).

Information on the master meter test table

- The temperature in the master meter table is at metering conditions (see 3.16 in R 81).
- The pressure of the product in the master meter table is at metering conditions (see 3.16 in R 81).
- The volume indication of the master meter is the total pulses divided by the K-factor (expressed as accumulated pulses per unit volume).
- In the master meter table, use temperature and pressure to obtain the density and correction factor (for non-linearity of the meter's K-factor as a function of temperature and pressure).
- Use the correction factor to obtain the volume indication of the master meter corrected for meter error.

Meaning of symbols and abbreviations used in this Annex

mpe = maximum permissible error	Calc. = calculated	Avg.= average
mmq = minimum measured quantity	Vol. = volume	Temp. = temperature
NBP = normal boiling point	Ind. = indication or indicated	H = horizontal
Ref. = reference	Corr. = corrected	V = vertical
EUT = equipment under test	n/a = not applicable	

For each examination and test, the checklist shall be completed according to one of these examples:

Pass	Fail
X	
	X
n/a	n/a

Page numbering

A space has been left on the top of each page (starting on page 7) for numbering the pages of reports established following this model. In particular, each test is reported individually on a separate page following the relevant format.

For a given report, it is advisable to complete the sequential numbering of each page by indicating the total number of pages in the report.

Pattern (type) evaluation test report

D.1 General information concerning the pattern (type)

Application No.: _____ Date: _____

Model designation: _____

Manufacturer: _____

Address: _____

_____

_____

Applicant: _____

Address: _____

_____

_____

Representative: _____

Telephone: _____ Fax: _____

E-mail: _____

Technical manual provided: _____

Operating manual provided: _____

Description of device or system: _____

_____

_____

_____

_____

_____

Accuracy class designation: _____

Maximum flowrate: _____

Minimum flowrate: _____

Unit for flowrate: _____

Minimum measured quantity (mmq): _____

Unit for mmq: _____

D.2 General information concerning the test conditions

Device submitted Model:_____ Serial No.:_____ Date:_____

A. Measurement standards

1. Gravimetric system Description: _____

Uncertainty: _____

Accuracy: _____

2. Volumetric system Description: _____

Uncertainty: _____

Accuracy: _____

Test liquid(s): _____

B. Environmental test equipment Description: _____

Temperature range: _____

Humidity range: _____

Disturbance test equipment: _____

Test location: _____

D.3 Metrological requirements: Checklist

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.3 Metrological requirements: Checklist

Clause	Title	PASS	FAIL	REMARKS
7	**Flowrates of a measuring system or meter**			
7.1	The maximum and minimum authorized flowrates for a measuring system are specified by the manufacturer.			
7.2	The ratio between the maximum and minimum flowrates of a meter shall be at least equal to 5.			
8	**Minimum measured quantity**			
8.1	The minimum measured quantity of the system shall be specified by the manufacturer.			
8.2	The minimum measured quantity shall not be less than 100 scale intervals.			
8.3	The value of the minimum measured quantity shall be in the form 1×10^n or 2×10^n or 5×10^n authorized units, n being a positive or negative whole number or zero.			

Remarks:

D.4 Technical requirements: Checklist

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist

Clause	Title	PASS	FAIL	REMARKS
9	**Indicating devices (indicators)**			
9.1	**General provisions**			
	Indications shall be in legal units as described in subclause 5.1 and shall be accompanied by the name or symbol of the unit.			
	Indications that are not subject to metrological control are allowed, provided that they cannot be confused with metrological information.			
	Reading of the indications shall be precise, easy and non-ambiguous when the indicating device comes to rest.			
	If the indicating device comprises several elements, the installation shall be arranged in such a way that the readings of the measurand can be effected by simple juxtaposition of the indications of the different elements.			
9.1.1	The scale interval of the indication shall be in the form of 1×10^n or 2×10^n or 5×10^n authorized units, n being a positive or negative whole number or zero.			
9.1.2	The indicated units specified in subclause 5.1 shall be clearly defined.			
9.1.3	The decimal mark shall appear distinctly.			

Remarks:

D.4 Technical requirements: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
9.2	**Zero-setting device**			
9.2.1	An indicating device may be provided with a device which returns the indication to zero either by manual operation or by automatic means.			
9.2.2	The zero-setting device shall not permit any alteration of the measurement result shown by the indicator (other than by making the result disappear and replacing it by zeros).			
9.2.3	Once the zeroing operation has begun it shall be impossible for the indicator to show a result different from that of the measurement which has just been made, until the zeroing operation has been completed.			
	Indicating devices shall not be capable of being reset to zero during measurement.			
9.3	**Totalizing indicator**			
	An indicator with a zeroing device may be equipped with a device for totalizing the different quantities shown successively by the indicator.			
	The totalizing indicator shall be non-resettable.			
10	**Printing devices (printers)**			
10.1	A printing device may be connected to an indicator.			

Remarks:

D.4 Technical requirements: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
10.2	The printed scale interval shall be the same as the scale interval of the indicator.			
10.3	The quantity printed shall be expressed in one of the units authorized for the indicator.			
	The unit used or its symbols, and the decimal mark if any, shall be indicated on the ticket.			
	The printed quantities shall be adequately and clearly defined.			
10.4	The printer may print other information identifying the measurement such as: serial number, date, place of measurement, type of liquid, etc.			
	The totalizing indicator shall be non-resettable.			
10.5	If a printer allows repetition of the printing before a new measurement has started, copies shall be clearly marked as such, for example by printing “duplicate”.			
10.6	For any quantity, the printed values shall be the same as those indicated.			
10.7	Printed ticket			
	In the case of a volume indication, the ticket shall have printed on it the base conditions in terms of gas or liquid.			
11	**Measuring systems**			
11.1	Maintenance of liquid state.			
	A measuring system shall be so designed and operated that the product being measured will remain in a liquid state during passage through the meter.			

Remarks:

D.4 Technical requirements: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
11.2	**Adjusting means**			
11.2.1	Meters shall be provided with adjusting means that permit adjustments of the ratio between the quantity indicated and the actual quantity of liquid which has passed through the measuring device.			
11.2.2	If the adjusting means modifies this ratio in a discontinuous manner, the consecutive values of the ratio shall not differ by more than 0.002.			
11.2.3	Adjustment by means of a by-pass on the measuring device is prohibited.			
11.3	**Sealing**			
	Sealing means shall be provided for those parts that can affect the accuracy of the measurement and the parameters (e.g. correction and conversion) that can affect the measurement results.			
11.3.1	Mechanical sealing			
	Mechanical sealing shall be carried out by means of lead and wire seals or other equally effective means.			
11.3.2	Electronic sealing			
	When access to parameters that affect the determination of the results of a measurement is not protected by mechanical sealing means, the protection shall fulfill the following:			
	• Access shall only be possible by such means as an alpha or numeric code, or "hard key". • An event counter (000-999) shall be provided to indicate that interventions have been made.			

Remarks:

D.4 Technical requirements: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
11.3.2 (Cont.)	The electronic sealing device shall have a means of identifying if an intervention occurs and by whom. The responsible national body may require such means as the use of labels or an event logger that includes an event counter, date and time of intervention, and the identity and value of the parameter changed.			
11.4	**Memory devices**			
11.4.1	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 dispute. Devices used to read stored information are considered as included in the memory devices.			
11.4.2	The medium on which the data are stored shall have sufficient permanency to ensure that the data are not corrupted under normal storage conditions.			
	Sealing means shall be provided for those parts that can affect the accuracy of the measurement and the parameters (e.g. correction and conversion) that can affect the measurement results.			
11.4.3	When the storage is full, memorized data may be deleted when the following conditions are met:			
	a. The rules established for the particular application are respected,			
	b. Data are deleted in the same order as the recording order, and			
	c. Deletion is carried out after a special manual operation.			
12	**Discharge lines**			
12.1	**Vapor return lines**			
	A vapor return line between the supplier's tank and the customer's tank shall not be permitted, unless this is required to complete a delivery.			

Remarks:

D.4 Technical requirements: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
12.2	**Directional flow valve**			
	Valve(s) or other means intended to prevent flow reversal, that is(are) automatic in operation shall be installed either on the outlet side of the meter or in the inlet line of the receiving tank.			
12.3	**Diversion of measured liquid**			
	No means shall be provided by which any measured liquid can be diverted from the measuring element of the meter or from the discharge line.			
	A manually controlled outlet that may be opened for purging or draining the measuring system shall be permitted.			
	Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the measuring system.			
12.4	**Transfer point**			
12.4.1	The measuring systems shall incorporate a transfer point.			
	The transfer point shall be located downstream of the meter in a delivery system, and upstream of the meter in a receiving system.			
12.4.2	The transfer point may be in the form of a closing device combined with a system which ensures the evacuation of the discharge hose after each measuring operation.			

Remarks:

D.4 Technical requirements: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.4 Technical requirements: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
12.5	**Valves and control mechanisms**			
	Check valves and closing mechanisms not used to define the measuring quantity shall, if necessary, have relief valves in order to dissipate any abnormally high pressures which may arise in the measuring system.			
	A vapor return line between the supplier's tank and the customer's tank shall not be permitted, unless this is required to complete a delivery.			
12.6	**Discharge hose**			
	The discharge hose of a measuring system shall be of the empty-hose type.			
13	**Markings**			
	A measuring system shall be legibly and clearly marked with the following information:			
a)	Pattern (type) approval mark;			
b)	Manufacturer's identification mark or trademark;			
c)	Designation selected by the manufacturer;			
d)	Serial number and year of manufacture;			
e)	Maximum and minimum flowrates, Q_{max} and Q_{min};			
f)	Maximum working pressure, P_{max};			
g)	Maximum and minimum temperatures, T_{max} and T_{min};			
h)	Minimum measured quantity, mmq.			

Remarks:

D.5 Requirements for electronic measuring systems: Checklist

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.5 Requirements for electronic measuring systems: Checklist

Clause	Title	PASS	FAIL	REMARKS
14.1	**General requirements**			
14.1.1	Electronic measuring systems shall be designed and manufactured such that their errors do not exceed the maximum permissible errors (mpe), as defined in clause 6, under rated operating conditions.			
14.1.1.1	Interruptible electronic measuring systems shall be designed and manufactured such that, when they are exposed to the disturbances specified in B.4, either:			
	a) significant faults do not occur, or			
	b) significant faults are detected and acted upon by means of checking facilities.			
	Note: This provision may apply separately to each individual cause of significant fault and/or each part of the measuring system.			
14.1.1.2	Non-interruptible electronic 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 B.4.			
14.1.2	It is the responsibility of the manufacturer to decide whether a given type of measuring system is interruptible or not, taking account of the applicable rules of security.			

Remarks:

D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
14.1.2.1	Measuring systems for direct selling to the public shall be interruptible.			
	When, at the time of pattern (type) approval, it is not possible to specify the future utilization of the instrument, the requirements in subclause 14.1.1.2 shall apply.			
14.1.3	Electronic measuring systems shall be provided with the checking facilities specified in subclause 14.3.			
14.1.4	A type of a measuring system is presumed to comply with the requirements in subclauses 14.1.1 and 14.1.3 if it passes the inspection and tests specified in subclause 15.1.10.			
14.1.5	When a significant fault occurs, measuring systems shall permit the retrieval of the information relating to the measured quantity, that is contained within the measuring system.			
14.2	**Power supply device**			
	When the flow is interrupted during a failure of the principal power supply device:			
	1. The measuring system shall be provided with an emergency power supply device to safeguard all the measuring functions during that failure; or,			
	2. Data contained at the moment of the failure shall be saved and displayed on the resumption of power on an indicating device subject to legal metrological control for a sufficient time to permit the conclusion of the current transaction.			

Remarks:

D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
14.2 (Cont.)	The absolute value of the maximum permissible error for the indicated volume is increased by 5 % of the minimum measured quantity (subclause 8.1).			
14.3	**Checking facilities**			
14.3.1	**Action of checking facilities**			
	The detection by the checking facilities of significant faults shall result in the following actions, according to the type:			
14.3.1.1a)	**Checking facilities of type I or P (non-interruptible)**			
	a) Non-interruptible measuring systems (such as pipelines) shall:			
	1. Have automatic correction of the fault, or			
	2. Allow stopping of the faulty device when the measuring system without that device continues to comply with the regulations, or			
	3. Have a visible or audible alarm for the operator; this alarm shall continue until such time as the cause of the alarm is suppressed (not applicable for the disturbances specified in B.4).			
	When the measuring system transmits data to any peripheral equipment, the transmission shall be accompanied by a message indicating the presence of a fault.			

Remarks:

D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
14.3.1.1 a) (Cont.)	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.			
14.3.1.1 b)	**Checking facilities of type I or P (interruptible) shall:**			
	1. Have automatic correction of the fault, or			
	2. Allow stopping only the faulty device, when the measuring system without that device continues to comply with the regulations, or			
	3. Allow stopping the flow.			
14.3.2	**Checking facilities for the measurement transducer**			
	The object of these checking facilities after the presence of the transducer has been confirmed, is to verify its correct operation and the correctness of data transmission.			
	Checking facilities shall provide a level of security equivalent to ISO 6551, part 3 Levels of security, 3.1.4 Level B, except for equipment with a cable length of 3 meters or less, for which 3.1.3 Level C applies. This requirement can be fulfilled without generating two pulses.			

Remarks:

D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
14.3.3	**Checking facilities for the calculator (Type P or I)**			
	The object of these checking facilities is to check if 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. The correct value of all data relating to the measurement shall be checked by the instrument whenever these data are transmitted to an ancillary device through an interface.			
	In addition, the calculation system shall be provided with a means for controlling the continuity of the calculation program.			
14.3.4	**Checking facilities for the indicating device (Type N)**			
	The object of this checking facility is to verify that the primary indications are displayed and correspond to the data provided by the calculator.			
	In addition, it aims at verifying the presence of the indicating devices, when they are removable.			
	The checking facility for the indicating device shall include at least a visual checking of the display as follows:			
	1. Displaying all the elements (“eights” test),			
	2. Blanking all the elements (“blank” test),			
	3. Displaying “zeros”.			
	Each step of the sequence shall last at least 0.75 second.			
	The produced signal shall originate from the calculator.			

Remarks:

D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.5 Requirements for electronic measuring systems: Checklist (Cont.)

Clause	Title	PASS	FAIL	REMARKS
14.3.5	**Checking facilities for an ancillary device**			
	Any ancillary device 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 validate the data transmitted by the calculator.			
	The object of the checking of a printing device is to ensure that the printing controls function properly so that output corresponds to the data transmitted by the calculator.			
	The presence of paper shall be checked.			
	Where the action of the checking facility is a warning, this shall be given on or by the ancillary device which is at its origin.			
14.3.6	**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 within a pre-determined measuring range.			

Remarks:

D.6 Summary of the tests

Application No.: _____

Model No.: _____

Serial No.: _____

Date: _____

Observer: _____

Table D.6 Summary of the tests

Clause	Title		PASS	FAIL	REMARKS
D.7	Tests for maximum errors (Flowrate and accuracy test)	A.1.3 - Liquids			
		A.1.4 - Flowrates			
D.8	Dry heat test (B.4.1)				
D.9	Cold test (B.4.2)				
D.10	Damp heat, cyclic test (B.4.3)				
D.11	Vibration test (B.4.4)				
D.12.1	AC power voltage variations test (B.4.5.1)				
D.12.2	DC power voltage variation test (B.4.5.2)				
D.13	Short-time power reduction test (B.4.6)				
D.14	Electrical burst test (B.4.7)				
D.15	Electrostatic discharge test (B.4.8)				
D.16	Electromagnetic susceptibility test (B.4.9)				
D.17	Perturbations on DC voltage powered instruments (B.4.10)				
D.18	Endurance test (A.1.5)				
D.19	Repeatability test (6.5 and A.1.2.1)				

Note: The repeatability test result (D.19) is based on tests conducted under D.7.1

Remarks:

D.7 Tests for maximum errors

D.7.1 Tests for maximum errors - Flowrate, accuracy and repeatability test (…..of 6) (A.1.2, A.1.3, A.1.4)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Flowrate: Nominal value (in % of Q_{max}) =_____%

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.7.1 Flowrate, accuracy and repeatability test (test for maximum errors) – at flowrate[2] #…
(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: Indications in mass

Test No.	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1					
2					
3					
Avg.					

Indications in liquid volume at NBP

Test No.	Flowrate (mass or volume unit/time)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1						
2						
3						
Avg.						

Indications in equivalent gas volume at base conditions

Test No.	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1							
2							
3							
Avg.							

MASTER METER TEST: Indications in mass

Test No.	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
1										
2										
3										
Avg.										

mpe[2] at flowrate #: **Passed:** ☐ **Failed:** ☐
Repeatability[1,2] at flowrate # : **Passed:** ☐ **Failed:** ☐

Notes 1. The repeatability shall not be greater than 1 % of the measured quantity (see 3.19, 6.5 of OIML R 81).
2. Copy this form and use for test at each flowrate (minimum 6). Indicate serial number of flowrate after #.

Remarks:

D.7.2 Tests for maximum errors - Minimum measured quantity (Ref. R 81: 15.1.5.2.2)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Flowrate: Nominal value (in % of Q_{max}) =_____%

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.7.2 Tests for maximum errors at minimum measured quantity
Minimum measured quantity: ----------

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Test No.	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1					
2					
3					
Avg.					

Indications in liquid volume at NBP

Test No.	Flowrate (mass or volume unit/time)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1						
2						
3						
Avg.						

Indications in equivalent gas volume at base conditions

Test No.	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1							
2							
3							
Avg.							

MASTER METER TEST: **Indications in mass**

Test No.	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
1										
2										
3										
Avg.										

Passed: ☐ Failed: ☐

Note: [1]Test to be performed if practical.

Remarks:

D.7.3 Tests for maximum errors – Flow disturbances (Ref. R 81: 15.1.5.2.2.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Flowrate: Normal value (in % of Q_{max}) = _____%

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.7.3 Tests for maximum errors with flow disturbances
Description of the disturbance: _____

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: Indications in mass

Test No.	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1					
2					
3					
Avg.					

Indications in liquid volume at NBP

Test No.	Flowrate (mass or volume unit/time)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1						
2						
3						
Avg.						

Indications in equivalent gas volume at base conditions

Test No.	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1							
2							
3							
Avg.							

MASTER METER TEST: Indications in mass

Test No.	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
1										
2										
3										
Avg.										

Passed: ☐ Failed: ☐

Notes: 1. Test to be performed if appropriate.
2. Copy this test form if several disturbances can be applied.

Remarks:

D.8 Dry heat test (B.4.1)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.8 Dry heat test

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Test No.	Reference temp.[1] (°C)	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1	20 °C					
2	max[1] =					
3	20 °C					

Indications in liquid volume at NBP

Test No.	Reference temp.[1] (°C)	Flowrate (mass unit/time)	Flowrate (mass unit/time)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1	20 °C						
2	max[1] =						
3	20 °C						

Indications in equivalent gas volume at base conditions

Test No.	Reference temp.[1] (°C)	Flowrate (mass unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1	20 °C							
2	max[1] =							
3	20 °C							

MASTER METER TEST: **Indications in mass**

Test No.	Refer-ence temp.[1] (°C)	Flowrate (mass or vol. unit/ time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indica-tion	Indicated value (mass unit)	Error %	mpe %
1	20 °C										
2	max[1] =										
3	20 °C										

Passed: ☐ Failed: ☐

Notes:

1. Maximum temperature shall be 55 ºC for Class C of I (Severity level 3) or 40 ºC for Class B (Severity level 2) (See B.4.3 of R 81).
2. Shall be tested at at least one flowrate.
3. Duration is 2 hours.
4. The temperature recorded in the table is the product temperature, measured in test measure or master meter.
5. All functions shall operate as designed.
6. All indications shall be within the maximum permissible errors.

Remarks:

D.9 Cold test (B.4.2)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.9 Cold test

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Test No.	Reference temp.[1] (°C)	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1	20 °C					
2	min[1] =					
3	20 °C					

Indications in liquid volume at NBP

Test No.	Reference temp.[1] (°C)	Flowrate (mass unit/time)	Flowrate (mass unit/time)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1	20 °C						
2	min[1] =						
3	20 °C						

Indications in equivalent gas volume at base conditions

Test No.	Reference temp.[1] (°C)	Flowrate (mass unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1	20 °C							
2	min[1] =							
3	20 °C							

MASTER METER TEST: **Indications in mass**

Test No.	Refer-ence temp.[1] (°C)	Flowrate (mass or vol. unit/ time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indica-tion	Indicated value (mass unit)	Error %	mpe %
1	20 °C										
2	min[1] =										
3	20 °C										

Passed: ☐ Failed: ☐

Notes:

1. Minimum temperature shall be -25 ºC for Class C of I (Severity level 3) or -10 ºC for Class B (Severity level 2) (See B.4.3 of R 81).
2. Shall be tested at at least one flowrate.
3. Duration is 2 hours.
4. The temperature recorded in the table is the product temperature, measured in test measure or master meter.
5. All functions shall operate as designed.
6. All indications shall be within the maximum permissible errors.

Remarks:

D.10 Damp heat. Performance test after cycle 2 (B.4.3)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.10 Damp heat. Performance test after cycle 2 (SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: Indications in mass

Test No.	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value[1] (mass unit)	Error %	mpe %
1					
2					
3					
Avg.					

Indications in liquid volume at NBP

Test No.	Flowrate (mass or volume unit/time)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1						
2						
3						
Avg.						

Indications in equivalent gas volume at base conditions

Test No.	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1							
2							
3							
Avg.							

MASTER METER TEST: Indications in mass

Test No.	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
1										
2										
3										
Avg.										

Passed: ☐ Failed: ☐

1. Pre-condition meter.
2. Apply damp heat cycles (duration 24 hours), 2 cycles between 25 ºC and 40 ºC for Class B (Severity level 1) or 55 ºC for Class C or I (Severity Level 2) (See B.4.3. of R 81).
3. Duration is 24 hours.
4. Maintain RH above 95 % during temperature changes and during phases of low temperature.
5. RH shall be 93 % or greater at the upper temperature range.
6. Test cannot be conducted by simulating the flow without any actual product passing through the measuring system.
7. All functions shall operate as designed.
8. All indications shall be within the maximum permissible errors.
9. After the damp heat test, a performance test under reference conditions consisting of three consecutive measurements for at least one flowrate is conducted.

Remarks:

D.11 Vibration test (B.4.4)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.11 Vibration test for Axis[9]

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

	Flowrate (mass/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
Before exposure					
After exposure					

Indications in liquid volume at NBP

	Flowrate (mass or volume unit)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
Before exposure						
After exposure						

Indications in equivalent gas volume at base conditions

	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
Before exposure							
After exposure							

MASTER METER TEST: **Indications in mass**

	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
Before exposure										
After exposure										

Passed: ☐ Failed: ☐

Notes:
1. Frequency range is from 10 Hz to 150 Hz.
2. Maximum acceleration level is 20 m/s^2.
3. Number of test cycles is 20 cycles per axis.
4. Test cannot be conducted by simulating the flow without any actual product passing through the measuring system.
5. The non-operational device 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.
6. The device shall be tested in its three, mutually perpendicular main axes, mounted on a rigid fixture by its normal mounting means.
7. It shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use.
8. After the vibration test, a performance test under reference conditions at least one flowrate is conducted.
9. Copy this form and use for test on each axis.

Remarks:

D.12 Power voltage variation test (B.4.5)
D.12.1 AC power voltage variation test (B.4.5.1)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.12.1 AC power voltage variation test
Marked nominal voltage (U_{nom})_____V
(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Test No.	Voltage 1	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1	Ref. volt.					
2	10 %					
3	-15 %					
Avg.	Ref. volt.					

Indications in liquid volume at NBP

Test No.	Voltage 1	Flowrate (mass or volume unit)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1	Ref. volt.						
2	10 %						
3	-15 %						
Avg.	Ref. volt.						

Indications in equivalent gas volume at base conditions

Test No.	Voltage 1	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1	Ref. volt.							
2	10 %							
3	-15 %							
Avg.	Ref. volt.							

Passed: ☐ Failed: ☐

Remarks:

…/cont'd

MASTER METER TEST: Indications in mass

Test No.	Voltage 1	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indica-tion	Indicated value (mass unit)	Error %	mpe %
1	Ref. volt.										
2	10 %										
3	-15 %										
Avg.	Ref. volt.										

Passed: ☐ Failed: ☐

Notes:

1. Shall be tested at at least one flowrate (or simulated flowrate), at the upper and lower voltage limits.
2. Number of cycles shall be one.
3. The test consists of exposure of the device to power voltage variations, while the device is operating under normal atmospheric conditions.
4. All functions shall operate as designed.
5. All indications shall be within the maximum permissible errors.

Remarks:

D.12.2 DC power voltage variation test (B.4.5.2)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.12.2 DC power voltage variation test
Marked nominal voltage (U_{nom})_____V
(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: Indications in mass

Test No.	Voltage	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
1	Nominal =					
2	Lower =					
3	Upper =					
Avg.	Nominal =					

Indications in liquid volume at NBP

Test No.	Voltage	Flowrate (mass or volume unit)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1	Nominal =						
2	Lower =						
3	Upper =						
Avg.	Nominal =						

Indications in equivalent gas volume at base conditions

Test No.	Voltage 1	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic metres)	Error %	mpe %
1	Nominal =							
2	Lower =							
3	Upper =							
Avg.	Nominal =							

Passed: ☐ Failed: ☐

…/cont'd

MASTER METER TEST: **Indications in mass**

Test No.	Voltage 1	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indica-tion	Indicated value (mass unit)	Error %	mpe %
1	Nominal										
2	Lower										
3	Upper										
Avg.	Nominal										

Passed: ☐ Failed: ☐

Notes:

1. Shall be tested at at least one flowrate (or simulated flowrate), at the upper and lower voltage limits.
2. Number of cycles shall be one.
3. The test consists of exposure of the device to power voltage variations.
4. All functions shall operate as designed.
5. Indications shall be within the maximum permissible errors.

Remarks:

D.13 Short-time power reduction test (B.4.6)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Marked nominal voltage, U_{nom} = _____

Table D.13 Short-time power reduction test

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Flowrate (mass unit/time)	Reference value (mass unit)	Disturbance				Result			
		Amplitude % of U_{nom}	Duration (ms)	Number of disturbances	Repetition intervals	Indication	Difference (unit)	Significant fault (fault > 20 % mpe)	
								No	Yes (remarks)
		Without disturbance							
		0	10	10					
		50	20	10					

Indications in liquid volume at NBP

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP	Disturbance				Result			
			Amplitude % of U_{nom}	Duration (ms)	Number of disturbances	Repetition intervals	Indication	Difference (unit)	Significant fault (fault > 20 % mpe)	
									No	Yes (remarks)
			Without disturbance							
			0	10	10					
			50	20	10					

Passed: ☐ **Failed:** ☐

Remarks:

Table D.13 Short-time power reduction test (B.4.6) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Marked nominal voltage, U_{nom} = _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Indications in equivalent gas volume at base conditions

Flowrate (mass unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	Disturbance				Result			
				Amplitude % of U_{nom}	Duration (ms)	Number of disturbances	Repetition intervals	Indication	Difference (unit)	Significant fault (fault > 20 % mpe)	
										No	Yes (remarks)
				Without disturbance							
				0	10	10					
				50	20	10					

MASTER METER TEST: **Indications in liquid volume at NBP**

Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Master meter vol. ind. corrected for meter error	Calc. mass from master meter indication	Disturbance				Result			
							Amplitude % of U_{nom}	Duration (ms)	Number of disturbances	Repetition intervals	Indication	Difference (unit)	Significant fault (fault > 20 % mpe)	
													No	Yes (remarks)
							Without disturbance							
							0	10	10					
							50	20	10					

Passed: ☐ **Failed:** ☐

Remarks:

D.14 Electrical bursts test (B.4.7)
D.14.1 Electrical bursts test for power supply lines (B.4.7)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Indicated value:_____ mass ☐ Liquid volume at NBP ☐ Volume of reference conditions ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

a) Power supply lines:

Number of test cycles	10	10
Marked nominal voltage, U_{nom} =		
Amplitude =		1 000 V

Table D.14.1 Electrical bursts test for power supply lines

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Flowrate (unit)	Ref. value (unit)	Disturbance: Line ↓ ground	Disturbance: Neutral ↓ ground	Disturbance: Protective Earth ↓ ground	Polarity	Result: Indication	Result: Significant fault (fault > 20 % mpe): No	Result: Significant fault (fault > 20 % mpe): Yes (remarks)
		Without disturbance						
		X			pos			
					neg			
		Without disturbance						
			X		pos			
					neg			
		Without disturbance						
				X	pos			
					neg			

Passed: ☐ **Failed:** ☐

Remarks:

Table D.14.1 Electrical bursts test for power supply lines (Cont.)

Indications in liquid volume at NBP

Flowrate (mass or volume unit/time)	Ref. value (mass unit)	Ref. value calc. to vol. at NBP	Disturbance			Polarity	Result		
			Line ↓ ground	Neutral ↓ ground	Protective earth ↓ ground		Indication	Significant fault (fault > 20 % mpe)	
								No	Yes (remarks)
			Without disturbance						
			X			pos			
						neg			
			Without disturbance						
				X		pos			
						neg			
			Without disturbance						
					X	pos			
						neg			

Passed: ☐ Failed: ☐

Remarks:

D.14.1 Electrical bursts test for power supply lines (B.4.7) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Indicated value: _____ mass ☐ Liquid volume at NBP ☐ _____ Volume of reference conditions ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

a) Power supply lines:

Number of test cycles	10	10
Marked nominal voltage, U_{nom} =		
Amplitude =		1 000 V

Table D.14.1 Electrical bursts test for power supply lines

(SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	Disturbance			Polarity	Result		
				Line ↓ ground	Neutral ↓ ground	Protective Earth ↓ ground		Indication	Significant fault (fault > 20 % mpe)	
									No	Yes (remarks)
				Without disturbance						
				X			pos			
							neg			
				Without disturbance						
					X		pos			
							neg			
				Without disturbance						
						X	pos			
							neg			

Passed: ☐ Failed: ☐

Remarks:

Table D.14.1 Electrical bursts test for power supply lines (Cont.)

MASTER METER TEST: **Indications in mass**

Flowrate (mass or volume unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Ref. value (mass unit)	Ref. value calc. to volume at NBP	Disturbance			Polarity	Result		
							Line ↓ ground	Neutral ↓ ground	Protective earth ↓ ground		Indication	Significant fault (fault > 20 % mpe)	
												No	Yes (remarks)
							X			pos			
										neg			
							Without disturbance						
								X		pos			
										neg			
							Without disturbance						
									X	pos			
										neg			

Passed: ☐ Failed: ☐

Remarks:

D.14.2 Electrical bursts test for I/O circuits and communication devices (B.4.7)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Indicated value:_____ mass ☐ Liquid volume at NBP ☐ _____ Volume of reference conditions ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

b) I/O circuits & communication devices

Number of test cycles	10	10
Marked nominal voltage, U_{nom} =		
Amplitude =		1 000 V

Table D.14.2 Electrical bursts test for I/O circuits and communication devices

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Flowrate (unit)	Ref. value (unit)	Tested cable/interface			Polarity	Result: Indication	Result: Significant fault (fault > 20 % mpe): No	Result: Significant fault (fault > 20 % mpe): Yes (remarks)
		Without disturbance						
		X			pos			
					neg			
		Without disturbance						
			X		pos			
					neg			
		Without disturbance						
				X	pos			
					neg			

Passed: ☐ **Failed:** ☐

Remarks:

Table D.14.2 Electrical bursts test for I/O circuits and communication devices (Cont.)

Indications in liquid volume at NBP

Flowrate (mass or volume unit/time)	Ref. value (mass unit)	Ref. value calc. to volume at NBP	Tested cable/interface			Polarity	Result		
							Indication	Significant fault (fault > 20 % mpe)	
								No	Yes (remarks)
			Without disturbance						
			X			pos			
						neg			
			Without disturbance						
				X		pos			
						neg			
			Without disturbance						
					X	pos			
						neg			

Passed: ☐ Failed: ☐

Remarks:

D.14.2 Electrical bursts test for I/O circuits and communication devices (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Indicated value:_____ mass ☐ Liquid volume at NBP ☐ _____ Volume of reference conditions ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

b) I/O circuits & communication devices

Number of test cycles	10	10
Marked nominal voltage, U_{nom} =		
Amplitude =	1 000 V	

Table D.14.2 Electrical bursts test for I/O circuits and communication devices (Cont.)

(SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Flowrate (mass or volume unit/ time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	Tested cable/interface			Polarity	Result		
								Indication	Significant fault (fault > 20 % mpe)	
									No	Yes (remarks)
				Without disturbance						
				X			pos			
							neg			
				Without disturbance						
					X		pos			
							neg			
				Without disturbance						
						X	pos			
							neg			

Passed: ☐ Failed: ☐

Remarks:

MASTER METER TEST: **Indications in mass**

Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Ref. value (mass unit)	Ref. value calc. to volume at NBP	Tested cable/interface			Polarity	Result		
											Indication	Significant fault (fault > 20 % mpe)	
												No	Yes (remarks)
							X			pos			
										neg			
							Without disturbance						
								X		pos			
										neg			
							Without disturbance						
									X	pos			
										neg			

Passed: ☐ **Failed** ☐

Remarks:

D.15 Electrostatic discharge test

D.15.1 Electrostatic discharge test – Direct application (B.4.8)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Air discharge ☐ Polarity (**): ☐ pos ☐ neg

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.15.1 Electrostatic discharge test - Direct application

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Type of test	Flowrate (unit)	Reference value (unit)	Discharges			Result		
			Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
							No	Yes (remarks)
Air discharge			Without disturbance					
			2					
			4					
			6					
			8					
Contact discharge			Without disturbance					
			2					
			4					
			6					

Passed: ☐ **Failed** ☐

Remarks:

Table D.15.1 Electrostatic discharge test - Direct application (Cont.)

Indications in liquid volume at NBP

Type of test	Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to volume at NBP	**Discharges**			**Result**		
				Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
								No	Yes (remarks)
Air discharge				Without disturbance					
				2					
				4					
				6					
				8					
Contact discharge				Without disturbance					
				2					
				4					
				6					

Passed: □ **Failed** □

Remarks:

**IEC 1000-4-2 specifies that the test shall be conducted with the most sensitive polarity.

D.15.1 Electrostatic discharge test - Direct application (B.4.8) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
Air discharge ☐ Polarity (**): ☐ pos ☐ neg

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Table D.15.1 Electrostatic discharge test - Direct application (Cont.)

(SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Type of test	Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value cal. to vol. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	**Discharges**			**Result**		
					Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
									No	Yes (remarks)
Air discharge					Without disturbance					
					2					
					4					
					6					
					8					
Contact discharge					Without disturbance					
					2					
					4					
					6					

Passed: ☐ **Failed** ☐

Remarks:

Table D.15.1 Electrostatic discharge test - Direct application (Cont.)

MASTER METER TEST: **Indications in mass**

Type of test	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Reference value (mass unit)	Ref. value calc. to volume at NBP	Discharges			Result		
								Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
												No	Yes (remarks)
Air discharge								Without disturbance					
								2					
								4					
								6					
								8					
Contact discharge								Without disturbance					
								2					
								4					
								6					

Passed: □ **Failed** □

Remarks:

**IEC 1000-4-2 specifies that the test shall be conducted with the most sensitive polarity.

D.15.2 Electrostatic discharge test test - Indirect application (B.4.8)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Indirect application - Contact discharge only

a) Vertical coupling plane Polarity (**): ☐ pos ☐neg

Table D.15.2.1 Electrostatic discharge test - Indirect application

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: Indications in mass

Flowrate (unit)	Reference value (unit)	Discharges			Result		
		Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
						No	Yes (remarks)
		Without disturbance					
		2					
		4					
		6					

Indications in liquid volume at NBP

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP	Discharges			Result		
			Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
							No	Yes (remarks)
			Without disturbance					
			2					
			4					
			6					

Passed: ☐ **Failed** ☐

Remarks:

**IEC 1000-4-2 specifies that the test shall be conducted with the most sensitive polarity.

D.15.2 Electrostatic discharge test - Indirect application (B.4.8) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Indirect application – Contact discharge only

a) Vertical coupling plane (Cont.) Polarity (**): ☐ pos ☐neg

Table D.15.2.1 Electrostatic discharge test - Indirect application (Cont.)

(SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value cal. to vol. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	**Discharges**			**Result**		
				Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
								No	Yes (remarks)
				Without disturbance					
				2					
				4					
				6					

MASTER METER TEST: **Indications in mass**

Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Vol. ind. master meter corrected for meter error	Calc. mass from master meter indication	**Discharges**			**Result**		
							Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication	Significant fault (fault > 20 % mpe)	
											No	Yes (remarks)
							Without disturbance					
							2					
							4					
							6					

Passed: ☐ **Failed** ☐

Remarks:

**IEC 1000-4-2 specifies that the test shall be conducted with the most sensitive polarity.

D.15.2 Electrostatic discharge test - Indirect application (B.4.8) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Indirect application – Contact discharge only

b) Horizontal coupling plane Polarity (**): ☐ pos ☐neg

Table D.15.2.2 Electrostatic discharge test - Indirect application

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Flowrate (mass unit/time)	Reference value (mass unit)	Discharges: Test voltage (kV)	Discharges: Number of discharges ≥ 10	Discharges: Repetition interval (s)	Result: Indication	Result: Significant fault (fault > 20 % mpe): No	Result: Significant fault (fault > 20 % mpe): Yes (remarks)
		Without disturbance					
		2					
		4					
		6					

Indications in liquid volume at NBP

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP	Discharges: Test voltage (kV)	Discharges: Number of discharges ≥ 10	Discharges: Repetition interval (s)	Result: Indication	Result: Significant fault (fault > 20 % mpe): No	Result: Significant fault (fault > 20 % mpe): Yes (remarks)
			Without disturbance					
			2					
			4					
			6					

Passed: ☐ **Failed** ☐

Remarks:

**IEC 1000-4-2 specifies that the test shall be conducted with the most sensitive polarity.

D.15.2 Electrostatic discharge test – Indirect application (B.4.8) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Indirect application – Contact discharge only

b) Horizontal coupling plane (Cont.) Polarity (**): ☐ pos ☐neg

Table D.15.2.2 Electrostatic discharge test - Indirect application (Cont.) (SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	**Discharges**			**Result**		
				Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication I	Significant fault (fault > 20 % mpe)	
								No	Yes (remarks)
				Without disturbance					
				2					
				4					
				6					

MASTER METER TEST: **Indications in mass**

Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Vol. ind. master meter corrected for meter error	Calc. mass from master meter indication	**Discharges**			**Result**		
							Test voltage (kV)	Number of discharges ≥ 10	Repetition interval (s)	Indication I	Significant fault (fault > 20 % mpe)	
											No	Yes (remarks)
							Without disturbance					
							2					
							4					
							6					

Passed: ☐ **Failed** ☐

Remarks:

**IEC 1000-4-2 specifies that the test shall be conducted with the most sensitive polarity report.

D. 15.3 Electrostatic discharge test – Test setup (B.4.8)

Specifications of test points (direct application), e.g. by photos or sketches

a) Direct application

Contact discharge:

Air discharge:

b) Indirect application

D.16 Electromagnetic susceptibility test (B.4.9 and 14.1.1)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Frequency range: 26 – 1 000 MHz
Field strength: 3 V/m
Modulation: 80 % AM, 1 kHz since wave
Rate of sweep: ☐

Table D.16 Electromagnetic susceptibility test

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Flowrate (mass unit/time)	Reference value (mass unit)	Disturbance				Result		
		Antenna	Frequency range (MHz)	Polarization	Facing	Indication	No	Yes (Remark)
		Without disturbance						
					Front			
					Right			
					Left			
					Rear			
					Front			
					Right			
					Left			
					Rear			

Table D.16 Electromagnetic susceptibility test (Cont.)

Indications in liquid volume at NBP

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (volume unit)	Disturbance				Result		
			Antenna	Frequency range (MHz)	Polarization	Facing	Indication	No	Yes (Remark)
			Without disturbance						
						Front			
						Right			
						Left			
						Rear			
						Front			
						Right			
						Left			
						Rear			

Passed: ☐ **Failed** ☐

Remarks:

D.16 Electromagnetic susceptibility test (B.4.9 and 14.1.1) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐
Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Frequency range: 26 – 1 000 MHz
Field strength: 3 V/m
Modulation: 80 % AM, 1 kHz since wave
Rate of sweep: ☐

Table D.16 Electromagnetic susceptibility test (Cont.)

(SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Flowrate (mass or volume unit/time)	Reference value (mass unit)	Ref. value calc. to vol.. at NBP (unit liq. vol. at NBP)	Ref. value calc. to gas vol. at base cond. (normal cubic meters)	Disturbance				Result		
				Antenna	Frequency range (MHz)	Polarization	Facing	Indication	No	Yes (Remark)
				Without disturbance						
							Front			
							Right			
							Left			
							Rear			
							Front			
							Right			
							Left			
							Rear			

MASTER METER TEST: **Indications in liquid volume at NBP**

Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indica-tion (liters)	Master meter K-factor	Vol. ind. master meter corrected for meter error	Calc. mass from master meter indica-tion	Disturbance				Result		
							Antenna	Frequency range (MHz)	Polarization	Facing	Indication	No	Yes (Remarks)
							Without disturbance						
										Front			
										Right			
										Left			
										Rear			
										Front			
										Right			
										Left			
										Rear			

Passed: □ **Failed** □

Remarks:

D.16 Electromagnetic susceptibility test - Test setup (B.4.9 and 14.1.1) (Cont.)

Description of the setup, e.g. by photos or sketches

D.17 Perturbations on DC voltage-powered instruments (B.4.10)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: (

Environmental conditions	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Density of test liquid: _____ kg/cm3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

1. Test pulses as in ISO 7637-2, 4.6.
2. Values agreed to between manufacturer & supplier.
3. The amplitudes are the values of Va, as defined for each test pulse in ISO 7637-2, 4.6.
4. If power < -15 % Unom or > +10 % Unom shall indicate within mpe or provide no indication that can be used as a measurement.
   (Minimum severity level for pattern (type) approval is level II)

Table D.17 Perturbations on DC voltage powered instruments

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Test pulse[1]	Selected test level[2]	Test levels[3] voltage			Minimum number of pulses or test time		Pulse cycle time		Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Error %	mpe %
		I	II	III			min.	max.					
1a													
1b													
2													
3a													
3b													

Indications in liquid volume at NBP

Test pulse[1]	Selected test level[2]	Test levels[3] voltage			Minimum number of pulses or test time		Pulse cycle time		Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value (mass unit)	Ref. value calc. vol. at NBP (unit liquid volume)	Error %	mpe %
		I	II	III			min.	max.						
1a														
1b														
2														
3a														
3b														

Passed: □ **Failed** □

Remarks:

D.17 Perturbations on DC voltage-powered instruments (B.4.10) (Cont.)

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

1. Test pulses as in ISO 7637-2.4.6.
2. Values agreed to between manufacturer & supplier.
3. The amplitudes are the values of Va, as defined for each test pulse in ISO 7637-2.4.6.
4. If power < -15% U_{nom} shall indicate within mpe or provide no indication that can be used as a measurement. (Minimum severity level for pattern (type) approval is level II)

Table D.17 Perturbations on DC voltage powered instruments (Cont.)

(SELECT ONLY ONE TABLE)

Indications in equivalent gas volume at base conditions

Test pulse[1]	Selected test level[2]	Test levels[3] voltage			Minimum number of pulses or test time		Pulse cycle time		Flowrate (mass/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. gas vol. at NBP (unit in normal cubic meters)	Error %	mpe %
		I	II	III			min.	max.							
1a															
1b															
2															
3a															
3b															

Table D.17 Perturbations on DC voltage powered instruments (Cont.)

MASTER METER TEST: **Indications in mass**

Test pulse[1]	Selected test level[2]	Test levels[3] voltage			Minimum number of pulses or test time		Pulse cycle time		Flowrate (mass/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. gas Vol. at NBP (unit in normal cubic meters)	Error %	mpe %
		I	II	III			min.	max.							
1a															
1b															
2															
3a															
3b															

Passed: □ **Failed** □

Remarks:

D.18 Endurance test (A.1.5, 15.1.5.3)

D.18.1 Performance test before endurance test

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____

1. Perform initial test, according to A.1.4 and 15.1.5.2 prior to endurance test
2. Error of initial test is within mpe: Yes ☐ No ☐
3. Operate for 100 hours at flowrate between 0.8 Q_{max} and Q_{max} with the liquid the device is intended to measure, or one with similar characteristics.
   Maximum flowrate of meter, Q_{max} = ☐
4. Perform final test with the same liquid, according to A.1.4 and 15.1.5.2. The test results shall not vary from the initial test by more than 1.5 % of the measured quantity.

Table D.18.1 Performance test before endurance test

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: **Indications in mass**

Test No.	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value[1] (mass unit)	Error %	mpe %
1					
2					
3					
Avg.					

Indications in liquid volume at NBP

Test No.	Flowrate (mass or volume unit/time)	Indicated value (unit – liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1						
2						
3						
Avg.						

Indications in equivalent gas volume at base conditions

Test No.	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref. value calc. to vol. at NBP (unit of liquid volume at NBP)	Ref. value calc. to gas vol. at base cond. (unit in normal cubic meters)	Error %	mpe %
1							
2							
3							
Avg.							

MASTER METER TEST: **Indications in mass**

Test No.	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Vol. ind. master meter corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
1										
2										
3										
Avg.										

Passed: ☐ Failed: ☐

Remarks:

D.18 Endurance test (A.1.5, 15.1.5.3) (Cont.)
D.18.2 Performance test after endurance test

Application No: _____
Model No.: _____
Serial No.: _____
Test liquid: _____
Date test performed: _____
Test type Simulated: ☐ Operational: ☐

Environmental conditions

	at start	at end	
Temperature:			°C
Rel. humidity:			%
Bar. pressure:			hPa
Time:			actual

Density of test liquid: _____ kg/cm^3 at _____ °C and at 101 325 Pa (NBP)
Observer: _____
After endurance testing:
Perform final test with the same liquid, according to A.1.4. and 15.1.5.2. The test results shall not vary from the initial test by more than 1.5 % of the measured quantity.

Table D.18.2 Performance test after endurance test

(SELECT ONLY ONE TABLE)

GRAVIMETRIC TEST: Indications in mass

Test No.	Flowrate (mass unit/time)	Indicated value (mass unit)	Reference value[1] (mass unit)	% Error	mpe %
1					
2					
3					
Avg.					

Indications in liquid volume at NBP

Test No.	Flowrate (mass or volume unit/time)	Indicated value (unit - liquid volume at NBP)	Reference value (mass unit)	Ref. value calc. to liquid vol. at NBP (volume unit)	Error %	mpe %
1						
2						
3						
Avg.						

Indications in equivalent gas volume at base conditions

Test No.	Flowrate (mass or volume unit/time)	Indicated value (normal cubic meters)	Reference value (mass unit)	Ref value calc. to vol. at NBP (unit of liquid volume at NPB)	Ref. value calc. to gas vol. at base cond. (unit in normal cubic meters)	Error %	mpe %
1							
2							
3							
Avg.							

MASTER METER TEST: Indications in mass

Test No.	Flowrate (mass or vol. unit/time)	Master meter temp. (°C)	Master meter pressure (kPa)	Master meter volume indication (liters)	Master meter K-factor	Vol. ind. master meter corrected for meter error	Calc. mass from master meter indication	Indicated value (mass unit)	Error %	mpe %
1										
2										
3										
Avg.										

Passed: ☐ Failed: ☐

Remarks: