ORGANISATION INTERNATIONALE

DE MÉTROLOGIE LÉGALE

INTERNATIONAL RECOMMENDATION

Pressure balances

Manomètres à piston

OIML R 110

Edition 1994 (E)

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 two main categories of OIML publications are:

1) **International Recommendations (OIML R),** which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;

2) **International Documents (OIML D),** which are informative in nature and intended to improve the work of the metrological services.

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

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

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

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

Bureau International de Métrologie Légale
11, rue Turgot - 75009 Paris - France
Telephone: 33 (1) 48 78 12 82 and 42 85 27 11
Fax: 33 (1) 42 82 17 27

*
* *

This publication - reference OIML R 110, edition 1994 (E) - was developed by the OIML subcommittee TC 10/SC 1 *"Pressure balances"*. It was approved for final publication by the International Committee of Legal Metrology in 1993 and will be submitted to the International Conference of Legal Metrology in 1996 for formal sanction.

PRESSURE BALANCES

1 Scope

This Recommendation applies to pressure balances equipped with either a simple-type or a re-entrant type piston-cylinder assembly, with direct loading, and which are used for measuring gauge pressure in the range from 0.1 MPa to 500 MPa. This Recommendation specifies the metrological and technical requirements applicable to these instruments, the methods for their testing, and the format of the test report. It also applies to the adjustment of weights used with pressure balances and to the calibration of pressure balances in cases where high accuracy is required.

The Recommendation does not apply to pressure balances with hydraulic multipliers, indicator-type pressure balances, pressure balances with the piston loaded by means of a lever-arm, controlled-clearance pressure balances, and pressure balances with electromagnetic balancing. It also does not apply to instruments that measure absolute pressure.

2 Terminology

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

2.1 Metrological characteristics of a pressure balance

2.1.1 Measuring range
The range of pressure to be measured with the pressure balance.

2.1.1.1 Upper limit of measuring range (P_{max})
The maximum pressure to be measured.

2.1.1.2 Lower limit of measuring range (P_{min})
The minimum pressure to be measured.

2.1.1.3 Conversion equation
An equation that relates the generated pressure and the mass of the used weights, taking into account the other input quantities.

2.1.2 Effective area
The area determined for a given piston-cylinder assembly which is used in the conversion equation for the calculation of the measured pressure.

2.1.3 Working stroke of the piston
The stroke of the piston within which the pressure balance maintains its metrological characteristics.

2.1.4 Rate of fall of the piston

The speed of fall of the piston at its operating level under specified conditions.

2.1.5 Free rotation time of the piston

The time during which the piston rotates freely after spinning to a specified rotation rate, until it stops.

2.2 Metrological properties of a pressure balance

2.2.1 Discrimination threshold

The smallest change in the measured pressure that produces a perceptible change in the response of the pressure balance.

2.2.2 Repeatability

The ability of a pressure balance to give uniform indications of the measured pressure for multiple applications of the same load under constant conditions of measurement.

2.3 Indication methods of a pressure balance

2.3.1 Indication by adding pressure values

The indication obtained by adding the pressure values stated on the loaded weights.

2.3.2 Indication by adding mass values and calculating pressure

The indication obtained by adding the mass values of the loaded weights and making the relevant calculation of the value of the measured pressure.

2.4 General terms for pressure measurement

2.4.1 True value of pressure

A pressure value that is perfectly consistent with the definition of pressure.

2.4.2 Conventional true value of pressure

A pressure value that is considered sufficiently close to the corresponding true value to be substituted for that value for purpose of the evaluation of errors.

2.4.3 Uncertainty of the pressure measurement

A parameter associated with the result of a pressure measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measured pressure.

2.4.4 Error of the pressure measurement

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

2.4.5 Maximum permissible errors

The maximum allowed difference (either positive or negative) between the pressure balance indication and the corresponding (conventional) true value of the measured pressure.

2.4.6 Accuracy class

Class of pressure balances that meet certain metrological requirements intended to keep errors within specified limits.

2.4.7 Calibration

The set of operations which establishes, under specified conditions, the relationship between the values of pressure indicated by a pressure balance and the corresponding values of pressure realized by a reference standard.

2.4.8 Cross float sensitivity

For a pressure balance tested by comparison against a standard pressure balance, the minimum change in load that results in a detectable change in the equilibrium of both the tested and the standard pressure balances.

2.5 General conditions

2.5.1 Rated operating conditions

The conditions of use of a pressure balance for which its metrological characteristics are intended to meet the requirements concerning maximum permissible errors.

2.5.2 Reference conditions

The conditions of use prescribed for testing the performance of a pressure balance or for intercomparison of measurement results.

2.6 Datum levels

2.6.1 Operating level of the piston

The level of the piston, with respect to a clearly defined part of the support column or the base of a pressure balance.

2.6.2 Pressure reference level

The vertical level, with respect to a clearly defined part of the support column or the base of a pressure balance, to which a measured pressure is related when the piston is at a specific operating level.

3 Description of the instrument

3.1 General

3.1.1 A pressure balance is an instrument intended for measuring the pressure of a medium, based upon the principle of balancing the force produced by the measured pressure on a known area with the gravitational force of known loaded weights, as realized with a piston-cylinder assembly.

3.1.2 In a pressure balance with direct loading, the balancing weights act directly on the piston.

3.1.3 In a pressure balance with a simple-type piston-cylinder assembly, the measuring system consists of a cylindrical piston and a simple cylinder, the atmospheric pressure acting on the exterior surface of the cylinder.

3.1.4 In a pressure balance with a re-entrant type piston-cylinder assembly, the measured pressure acts over a portion of the exterior surface of the cylinder.

3.1.5 In a pressure balance with a controlled-clearance type cylinder, an independently controlled pressure acts on the exterior surface of the cylinder or over a portion of that surface.

3.2 Main components

3.2.1 A piston-cylinder assembly is composed of a piston of cylindrical shape inserted in a cylinder. A weight carrier may be fixed on the free end of the piston.

3.2.2 The holder of the piston-cylinder assembly is that part of the instrument in which the piston-cylinder assembly is fixed and sealed.

3.2.3 The frame or base of the instrument ensures the stability of the piston-cylinder assembly and its vertical position by means of a levelling device and serves for the attachment of auxiliary parts of the instrument, e.g. pressure pipes, press, valves, etc.

3.3 Auxiliary components

3.3.1 The press is a device which is not necessarily part of the pressure balance itself, and which is intended to produce and control the measured pressure by volume changes; this device usually consists of a piston sealed in a cylinder.

3.3.2 The plumbing are tubes or pipes which connect individual parts of the instrument's pressure system and which are equipped with one or more valves for disconnecting individual parts during a test.

3.3.3 The loading weights are a set of plates which are suitably graded for the measurement of the required pressure values.

3.4 Unit of measurement

The unit of measurement to be used with pressure balances is the pascal (Pa). Manufacturers shall provide conversion factors for other units of measurement.

4 Metrological requirements

4.1 Measuring range

The upper limit of the measuring range of a pressure balance, P_{max}, should be selected from the following two series:

- 1×10^n, 1.6×10^n, 2.5×10^n, 4×10^n, 6×10^n (MPa)
- 1×10^n, 2×10^n, 5×10^n (MPa)

where n is a positive or negative integer number, or zero.

4.2 Division of a measuring range

For the application of maximum permissible errors, the measuring range of a pressure balance with $P_{min} < 0.1\ P_{max}$ is divided into two parts:

- the main measuring range from $0.1\ P_{max}$ to P_{max}, and
- the supplementary measuring range from P_{min} to $0.1\ P_{max}$.

For pressure balances with $P_{min} \geq 0.1\ P_{max}$, there is only a main measuring range from P_{min} to P_{max}.

4.3 Accuracy classes

Pressure balances are classified into the following accuracy classes:

0.005 0.01 0.02 0.05 0.1 0.2

Pressure balances of higher accuracy classes may be developed in the future.

The accuracy class of a pressure balance shall be determined by calibration.

4.4 Maximum permissible errors

The maximum permissible errors for pressure balances shall be the same at pattern approval and at initial and subsequent verifications.

The maximum permissible errors for pressure balances under reference conditions, i.e. at a temperature of 22 °C ± 3 °C and for the standard acceleration due to gravity (9.80665 m/s^2), are given in Table 1 for the various accuracy classes. They are expressed as percentages of the measured pressure within the main measuring range, and as percentages of the lower limit of the main measuring range (0.1 P_{max}) within the supplementary measuring range, if existing.

Table 1

Accuracy class	Maximum permissible errors	
	Throughout the main measuring range (as percentage of the measured pressure)	Throughout the supplementary measuring range, if existing (as percentage of 0.1 P_{max})
0.005	0.005	0.005
0.01	0.01	0.01
0.02	0.02	0.02
0.05	0.05	0.05
0.1	0.1	0.1
0.2	0.2	0.2

4.5 Uncertainty of a pressure balance

The uncertainty of a pressure balance shall be calculated from the evaluation of the individual uncertainties of the measured quantities and those of the predetermined quantities used for calculating the measurement result.

4.5.1 Individual uncertainties

The uncertainties of the measured and predetermined quantities may be divided into the following groups:

a) uncertainty of the determination of the effective area (given by the uncertainty of the standard pressure balance used and by certain partial uncertainties of the method), which includes:
   - uncertainty of the piston-cylinder assembly deformation coefficient,
   - uncertainty due to temperature influences (measurement of the temperature of the assembly, determination of the thermal expansion coefficient of the assembly material);

b) uncertainties of the masses of the weights (determination of the masses and their adjustment, if performed);

c) uncertainties resulting from other influence quantities:

- determination of the acceleration due to gravity,
- vertical deviation of the piston,
- determination of the difference in reference levels,
- determination of the density of the pressure medium,
- cross float sensitivity.

4.5.2 Uncertainties resulting from other influence quantities

The uncertainties listed in 4.5.1(c) are usually not evaluated by tests. The instructions and constants given in the operation manual of the pressure balance shall be presented in such a way that the global effect of these uncertainties may be maintained at the minimum practical level, for example less than 10 % of the total uncertainty (see 4.5.3).

4.5.3 Total uncertainty of the pressure balance

Each of these uncertainty groups is to be evaluated independently.

The root-sum-of-squares of all uncertainties, determined following A.5.8, and after application of all corrections, shall not exceed half the maximum permissible error as specified in 4.4.

Note: It is advisable that the values of the different uncertainty groups, expressed as percentages of the total uncertainty, follow the distribution:

4.5.1(a): 50 %
4.5.1(b): 40 %
4.5.1(c): 10 %

4.6 Free rotation time of the piston

The free rotation time of the piston shall conform to the manufacturer's specifications. In the absence of any specification, the free rotation time of the piston shall not be less than the values given in Table 2 under the conditions specified in A.5.1.1.

Table 2

Upper limit of the measuring range (MPa)	Free rotation time (min) for accuracy class					
	0.005	0.01	0.02	0.05	0.1	0.2
from 0.1 to 6 included	4	4	3	2	2	2
over 6 to 500 included	6	6	5	3	3	3

Note: A pressure balance with a piston rotation provided by a motor shall comply with these conditions with the motor off and disconnected.

4.7 Rate of fall of the piston

The rate of fall of the piston shall conform to the manufacturer's specifications. In the absence of any specification, the rate of fall of the piston shall not exceed the values given in Table 3 under the conditions specified in A.5.2.1.

Table 3

Pressure medium in clearance	Upper limit of the measuring range (MPa)	Maximum piston fall rate (mm/min) for accuracy class 0.005	0.01	0.02	0.05	0.1	0.2
gas	0.1 to 1 included	1	1	1	2	2	–
gas	more than 1	2	2	2	3	3	–
liquid	0.6 to 6 included	0.4	0.4	0.4	1	2	3
liquid	from 6 to 500 included	1.5	1.5	1.5	1.5	3	3

4.8 Adjustment of the mass of weights

When applicable, the weights of new pressure balances shall be adjusted by the manufacturer for use under specific conditions. The values of these weights shall not differ from that given by the calculation (see Annex B) by more than the values stated in Table 4. For pressure balances of higher accuracy, the weights need not be adjusted according to Table 4 if their true mass is used to calculate the measured pressure.

Table 4

Accuracy class	Maximum permissible errors (relative values) for the adjustment of the mass of the weights
0.005	0.5×10^{-5}
0.01	1.5×10^{-5}
0.02	1.5×10^{-5}
0.05	5×10^{-5}
0.1	16×10^{-5}
0.2	16×10^{-5}

4.9 Calculation of the pressure (indication of the pressure balance)

The measured pressure is calculated according to the conversion equation given in the operation manual or is determined by summation of the values marked on the weights used. When the conversion equation is used, the uncertainties of the data used in the calculation shall be such that the total uncertainty does not exceed half the maximum permissible error of the pressure balance.

4.10 Discrimination threshold

The value of the discrimination threshold of a pressure balance, measured at a pressure equal to the lower limit of the main measuring range, shall not exceed 10 % of the value of the maximum permissible error as specified in 4.4.

5 Technical requirements

5.1 Environmental conditions

Pressure balances are generally intended for use under the following environmental conditions:

- temperature within the range + 15 °C to + 30 °C,
- maximum relative humidity of the ambient air: 80 %.

Other environmental conditions for use of a pressure balance may be specified by the manufacturer.

5.2 Condition of the pressure balance

A pressure balance shall not display significant traces of corrosion or damage capable of influencing its metrological characteristics.

5.3 Means for observing and determining the piston's vertical level

A pressure balance shall incorporate a means for observing and determining the piston's vertical level during measurements within the range of its stroke. The sensitivity of this means shall be sufficient to detect any change in the position of the piston corresponding to a pressure variation equal to 10 % of the maximum permissible error of the pressure balance at the lower limit of the main measuring range as specified in 4.4.

5.4 Levelling indicating device

A pressure balance shall have a means for adjusting the verticality of the piston-cylinder assembly axis and for indicating that this has been accomplished with a maximum permissible deviation of 5 arcminutes.

5.5 Mutual positions of the weight carrier loading surface and the piston

If the loading surface of the weight carrier is fixed to the piston, it shall be perpendicular to the piston axis so that the uncertainty component due to deviation from verticality does not exceed the requirements given in 5.4.

5.6 Requirements for the weights

5.6.1 Total mass of the weights

The total mass of the weights supplied with a pressure balance shall be sufficient for reaching the upper limit of the measuring range.

5.6.2 Gradation of the weights

The masses of the weights should correspond to the nominal pressure values from the series (1, 2, 5) $\times 10^n$ pressure units, where n is an integer number. Other values may be used in special cases (in particular, see 5.6.3 and 5.6.4).

5.6.3 Mass of the first weight

The mass of the first weight necessary for obtaining a pressure corresponding to the lower limit of the measuring range need not produce a pressure corresponding to a value as specified in 5.6.2.

5.6.4 Weights of pressure balances of higher accuracy

No restrictions shall be placed on mass values of pressure balances of accuracy classes 0.005, 0.01 and 0.02 which are usually used for calibration or other special purposes.

5.6.5 Shapes and dimensions of weights of equal mass

Weights of equal nominal mass belonging to the same pressure balance should be of the same shape and dimensions.

5.6.6 Loading of the weights

The weights balance should be stacked up on the weight carrier in alignment with the rotation axis and in a manner which facilitates their loading and unloading.

5.6.7 Material of the weights

The weights should be manufactured with materials resistant to abrasion and corrosion or be provided with a protective surface coating for ensuring their mass stability during use. The stability shall be such that the mass variations under normal conditions of use are negligible with respect to the maximum permissible errors. The weights of pressure balances of accuracy classes 0.005, 0.01 and 0.02 shall be made of a non-magnetic material.

5.7 Material of the piston-cylinder assembly

The material used for manufacturing the piston-cylinder assembly shall comply with the requirements for the material of the weights as specified in 5.6.7 and shall have a stable shape and volume for ensuring the long-term stability on the effective area of the pressure balance. The manufacturer should provide information concerning the stability and qualities of the material used.

5.8 Leak-tightness of the pressure system of a pressure balance

The leak-tightness shall be tested by measuring the piston fall rate which shall comply with the requirement in 4.7.

5.9 Markings

5.9.1 A pressure balance shall bear the following markings:

- name or trade-mark of the manufacturer,
- serial and model number,
- year of manufacture,
- accuracy class,
- pressure measuring range(s), and
- pattern approval number, if required by national regulations.

5.9.2 Each part of the piston-cylinder assembly, i.e. the cylinder, the piston, and the weight carrier in case it is fixed to a piston, shall bear or be accompanied by the following data:

- unique serial (identification) number or mark, and
- nominal pressure generated by the assembly under standard conditions if the piston's weight and that of the weight carrier are adjusted.

5.9.3 Each pressure balance weight shall bear the following data:

- unique serial (identification) number or mark for the set,
- identification number of each weight, when the weights are adjusted for a given piston-cylinder assembly, and
- nominal pressure in MPa (kPa) generated by the weight under standard acceleration due to gravity, or nominal mass of the weight.

5.10 Documentation of a pressure balance

5.10.1 The operation manual of a pressure balance shall contain:

a) detailed instructions regarding its transportation, storage, assembly, use, and maintenance, as well as a method for checking for significant magnetization of the piston and cylinder and, if necessary, a method for demagnetizing these components; and

b) mathematical relationships used in the calculation of pressure as a function of the values of weights used, temperature, local acceleration due to gravity, etc.

5.10.2 A calibration report shall contain the following, in addition to the data and test results according to Annex D:

a) mathematical relationships used in the calculation of pressure during calibration; and

b) total uncertainty of the pressure balance under reference conditions.

6 Metrological controls

6.1 Pattern approval

6.1.1 According to national regulations, pattern approval of pressure balances subject to metrological controls shall be granted following examinations and tests performed in an authorized laboratory. The pattern approval tests shall be carried out on a maximum of three samples of the pattern submitted by the manufacturer or its representative or distributor.

6.1.2 The applicant shall provide the documentation required in 5.10 with each sample of the pressure balance presented for pattern evaluation. In addition, the following information shall be provided:

- diagrams of the instrument's assembly and of other components of importance from the metrological point of view, and specification of the kind of material used for the manufacture of the piston-cylinder assembly, with relevant physical constants,
- brief functional description of the pressure balance,
- brief technical description of the measuring and testing method used during manufacture and specification of the procedure for calculating effective area values, pressure values, and any correction coefficient,
- any other information for demonstrating that the instrument meets the requirements.

6.1.3 The operation manual shall be reviewed for completeness. The instrument shall be inspected visually to determine whether the requirement in 5.2 has been met.

6.1.4 The authorized laboratory shall carry out the following performance tests according to Annex A, or may accept the test data supplied by the manufacturer confirming acceptable instrument performance:

- sensitivity of the means for observing the position of the piston (5.3),
- alignment of the piston axis with the local gravitational field (5.4 and A.4.1, A.4.3),
- perpendicularity of the piston axis with respect to the loading surface of the weight carrier (5.5 and A.4.4),
- leak-tightness of the instrument (5.8 and A.4.5),
- free rotation time of the piston (4.6 and A.5.1),
- rate of fall of the piston (4.7 and A.5.2),
- discrimination threshold (4.10 and A.5.3),
- determination of the masses of the piston and weights (4.8, 5.6, A.5.6, and Annex B),
- determination of the effective area (A.5.5),
- tests on the masses of the piston with weight carrier and that of other weights (A.5.4, A.5.6, and Annex B),
- pressure deformation coefficient (A.5.7, and Annex C),
- total uncertainty of the pressure balance (4.5 and A.5.8).

6.1.5 The results of the tests carried out for pattern approval should be reported according to the format provided in Annex D.

6.1.6 When the examinations and tests are successful, the applicant shall be provided with a pattern approval certificate as specified in national regulations.

6.2 Initial and subsequent verification

6.2.1 According to national regulations, initial and subsequent verifications should only be carried out in an authorized laboratory and on pressure balances that have been manufactured according to an approved pattern.

6.2.2 Pressure balances submitted for verification shall meet the same requirements as those specified for pattern approval.

6.2.3 Pressure balances that meet the requirements for verification may be provided with an verification mark or certificate. This certificate shall contain the same information as that specified for pattern approval.

6.2.4 If a pressure balance does not meet the verification requirements for the accuracy class for which it was submitted but fulfills those of a lower accuracy class, a verification certificate may be issued for the lower accuracy class at the applicant's request.

ANNEX A

TEST METHODS
(Mandatory)

A.1 Test equipment

The following test equipment is used:

- standard pressure balance with an appropriate measuring range and accuracy class according to A.5.5.2.1,
- standard mass balance with associated masses, or weights provided by the applicant, for determining the mass of the instrument's weights and piston with weight carrier with a maximum permissible error as specified in 4.8,
- auxiliary equipment such as level indicator, thermometer, position indicator, etc.

Note 1: A standard mass balance is not necessary if the applicant has a certificate stating the masses of the instrument's weights and piston with weight carrier, issued by an authorized laboratory.

Note 2: In special cases, standard manometers other than pressure balances may be used for testing a pressure balance; however, the test method using such standard manometers is not covered by this Recommendation.

A.2 Testing and reference conditions

Testing shall be carried out in an air-conditioned laboratory under the following conditions:

- ambient temperature: 22 °C ± 3 °C; relative humidity 60 % ± 20 %,
- stability of the ambient temperature around the instrument better than 1 °C per hour during the tests,
- rate of air circulation less than 1 m/s,
- placement of the pressure balance and testing equipment in the laboratory at least 6 hours before the test,
- pressure balance appropriately levelled according to the operation manual provided by the manufacturer,
- temperature of the pressure balance measured with an appropriate thermometer with a maximum uncertainty of 0.1 °C.

The reference conditions shall be:

- temperature: 22 °C ± 3 °C,
- standard acceleration of gravity (9.80665 m/s^2), and the test report shall be issued for these reference conditions.

A.3 Visual examination

A.3.1 Documentation

Check the submitted documentation including operation manual, to determine whether it is complete.

A.3.2 Design documentation (only for pattern approval)

Check the design documentation to find out whether it adequately describes the submitted sample(s) of the pattern of the pressure balance.

A.3.3 Pressure balance

Check the pressure balance to find out whether it fulfills the technical requirements of clause 5 which do not require testing.

A.4 Tests for compliance with the technical requirements

A.4.1 Initial set up

The pressure balance shall be set up according to the manufacturer's specifications using tools and measuring instruments included with the pressure balance accessories or recommended by the manufacturer. Special attention should be given to the cleanliness of the system, especially to the piston and cylinder, and to the verticality of the piston axis.

A.4.2 Means for observing the piston's vertical level

The means used for observing the piston's vertical level shall be tested by comparison with a cathetometer or any equivalent instrument.

A.4.3 Levelling indicating device

The test shall be carried out before loading the weights. The verticality of the piston axis is checked by a calibrated bubble level.

If the manufacturer does not describe a specific procedure for checking the alignment of the piston axis with the vertical, the following procedure should be used:

- set the levelling device included in the pressure balance so that the indicating device shows a vertical alignment of the piston axis according to the manufacturer's specifications;
- float the piston at its operating position;
- place a calibrated bubble level on the upper surface of the piston or on a special fixture designed for this purpose; the uncertainty of the calibrated bubble level shall be within one arcminute.
- the piston is properly aligned if the requirements of 5.4 are met.

A.4.4 Perpendicularity of the piston axis and weight carrier

This test applies when the weight carrier and the piston are permanently connected and shall be carried out before loading the weights. After the piston axis has been vertically aligned, the calibrated bubble level is placed on the upper surface of the weight carrier in two directions perpendicular one to the other. The deviation of the indication of the calibrated bubble level placed in these two directions shall meet the requirements of 5.5.

A.4.5 Leak-tightness of the instrument's pressure system

The pressure within the instrument shall be increased up to the upper limit of the measuring range of the pressure balance; this pressure shall be maintained until the system has reached thermal equilibrium (5–30 min). The instrument's pressure system shall then be disconnected from the pressure source, and the leak-tightness of the instrument shall be observed by measuring the piston fall rate with the piston rotating. The requirements in 4.7 shall be met.

A.5 Tests for compliance with the metrological requirements

A.5.1 Free rotation time of the piston

A.5.1.1 The free rotation time of piston shall be determined under the following conditions:

a) the measuring system of the instrument shall contain a pressure medium according to the manufacturer's specifications,

b) the pressure shall be equal to 20 % of the upper limit of the measuring range,

c) the initial rotation rate of the piston shall not exceed the value specified by the manufacturer, or $(2 \pm 0.15)\ s^{-1}$ when no value is specified,

d) the piston-cylinder assembly shall be at the reference temperature or at a temperature within the operating temperature range specified by the manufacturer (see A.5.1.2),

e) two successive tests shall be performed with the piston rotating in opposite directions.

A.5.1.2 In case the temperature of the piston-cylinder assembly deviates from the reference temperature by more than 2 °C, the free rotation time shall be calculated according to the equation:

$$\tau_r = \tau \cdot \frac{\eta}{\eta_r} \qquad (1)$$

where

τ_r is the free rotation time of the piston at reference temperature,

τ is the rotation time of piston at measurement temperature,

η_r is the dynamic viscosity of the pressure medium at reference temperature, and

η is the dynamic viscosity at measurement temperature.

Note: The equation is valid provided that the piston and cylinder are made of the same material.

A.5.1.3 Measurement accuracy for time, rotation, and temperature shall be as follows:

- the piston free rotation time shall be measured with an uncertainty not exceeding ± 10 seconds,
- the piston-cylinder assembly temperature shall be measured with an uncertainty not exceeding ± 0.5 °C,
- the initial piston rotation rate shall be measured with an uncertainty not exceeding $\pm 0.15\ s^{-1}$.

A.5.1.4 The requirements in 4.6 shall be met.

A.5.2 Rate of fall of the piston

A.5.2.1 The rate of fall of the piston shall be determined under the following conditions:

a) the instrument's measuring system shall contain a pressure medium according to the manufacturer's specifications,

b) the pressure shall be equal to the upper limit of the measuring range,

c) the piston-cylinder assembly shall be close to the reference temperature or within the operating temperature range specified by the manufacturer (see A.5.2.2),

d) to the farthest extent possible, the instrument shall be isolated from any other plumbing.

A.5.2.2 In case the piston-cylinder assembly temperature deviates from the reference temperature by more than 1°C, the rate of fall shall be calculated according to the equation:

$$V_r = V \cdot \frac{\eta}{\eta_r} \tag{2}$$

where

V_r is the rate of fall at reference temperature,
V is the rate of fall at measurement temperature,
η is the dynamic viscosity of the pressure medium at measurement temperature, and
η_r is the dynamic viscosity of the pressure medium at reference temperature.

A.5.2.3 The rate of fall shall be measured with a relative uncertainty not exceeding 5 % and the measurement shall not be carried out until thermal equilibrium has been achieved.

A.5.2.4 The test shall be repeated three times and the mean value of the three measurements shall be considered as the test result.

A.5.2.5 The requirements in 4.7 shall be met.

A.5.3 Discrimination threshold

A.5.3.1 The discrimination threshold test shall be carried out at a pressure corresponding to the upper limit of the measuring range.

A.5.3.2 This test shall be carried out by comparison with a standard pressure balance. A weight corresponding to a pressure variation of 10 % of the maximum permissible error shall be added to the pressure balance under test.

A.5.3.3 The requirement in 4.10 shall be met, i.e. a measurable change in the rate of fall of the piston or in the differential pressure indication shall be observed.

A.5.4 Determination of the masses of the piston with weight carrier and those of individual weights

A.5.4.1 The masses of the piston with weight carrier and those of individual weights shall be determined by means of the standard mass balance with standard weights, if applicable.

Note: This mass determination is not necessary if the applicant has a certificate of mass calibration issued by an authorized laboratory.

A.5.4.2 The accuracy of the determination of the masses of the piston with weight carrier and of the individual weights shall comply with the requirement in 4.8.

A.5.5 Determination of the effective area

A.5.5.1 Method of determination

A.5.5.1.1 The determination of the effective area of a pressure balance shall be carried out by comparison with a standard pressure balance under the conditions stated in A.5.5.3.

A.5.5.1.2 The hydrostatic comparison with the standard pressure balance shall be carried out by using either of the following methods:

a) direct balancing:
   the comparison of the pressure balances shall be performed at certain test pressures by loading adequate weights and by adding small weights usually onto the standard pressure balance;
b) direct balancing with previous balancing:
   before balancing at various testing pressures, the pressure balance under test is adjusted to the lower limit of its measuring range by using small weights which shall not be taken into account in the measurement result; only the weights necessary for obtaining the test pressures shall be taken into account.

A.5.5.2 General requirements

A.5.5.2.1 The standard pressure balance used for testing a pressure balance of accuracy class 0.05, 0.1, or 0.2, shall be of an accuracy class at least two times higher than that under test.

The standard pressure balance used for testing a pressure balance of accuracy class 0.005, 0.01, or 0.02, shall have an uncertainty such that, when combined with the uncertainty of the test method, the total uncertainty is better than 0.005 %, 0.01 %, or 0.02 %, of the value of the test pressure.

A.5.5.2.2 The test shall be carried out at pressure values which are gradually increased up to the upper limit of the instrument's measuring range and then gradually decreased. The number of pressure values and their distribution over the instrument's measuring range shall be determined according to Table 5.

Table 5
Number of the test pressure values
and their distribution

Accuracy class			Number of values	Nominal values of the pressure values as percentages of the upper limit of the instrument's measuring range									
0.005	0.01	0.02	10	10	20	30	40	50	60	70	80	90	100
0.05	0.1	0.2	6	10	20	40	60	80	100				

Note: When testing a pressure balance of accuracy class 0.005, 0.01, or 0.02, up to three pressure values may be omitted provided that they are not adjacent.

A.5.5.2.3 The mutual vertical positions of the datum levels of both the pressure balance under test and the standard pressure balance during the test shall be determined with an accuracy adequate for ensuring that the pressure measurement uncertainty component due to this influence quantity does not exceed 10 % of the maximum permissible error specified in 4.4.

A.5.5.2.4 During the comparison, the piston rotation rates at each test point, when the pistons of both pressure balances are in their working positions, shall be such that they ensure an optimal sensitivity for the instruments, as specified in the operation manuals.

A.5.5.2.5 During the comparison, the balancing is considered to be sufficient when there are no obvious differences or changes observed in the rates of fall of the pistons of both pressure balances. In this state, the addition or removal of a small weight of a value corresponding to the pressure equal to 10 % of the maximum permissible error of the instrument, shall cause an obvious change in the rate of fall of the piston.

Note: During the testing, the pressure balance under test may be separated from the standard balance by means of a sensitive differential pressure indicator capable of measuring small pressure differences between the two pressure balances.

A.5.5.3 Calculation of the effective area

A.5.5.3.1 The value of the effective area is determined as the average of individual values obtained from the results of the comparison with the standard pressure balance and by using the following equation:

$$A_{i,o} = \frac{\left[m \cdot \left(1 - \frac{\varrho_b}{\varrho}\right) + m_i \cdot \left(1 - \frac{\varrho_b}{\varrho_i}\right) + \frac{\gamma \cdot C}{g} \right] \cdot A_{et} \cdot (1 + \Phi_i + \Lambda_i)}{m_{et} \cdot \left(1 - \frac{\varrho_b}{\varrho_{et}}\right) + m_{et,i} \cdot \left(1 - \frac{\varrho_b}{\varrho_{et,i}}\right) + (\varrho_F - \varrho_b) \cdot A_{et} \cdot H + \frac{\gamma \cdot C_{et}}{g}} \tag{3}$$

where

$A_{i,o}$ is the effective area of the pressure balance under test, under zero pressure and at reference temperature, for the i-th equilibrium,

A_{et} is the effective area of the standard pressure balance, under zero pressure and at reference temperature,

m_{et}, m are the masses of the pistons and weight carriers of the standard pressure balance and pressure balance under test,

ϱ_{et}, ϱ are the densities of the pistons and weight carriers of the standard pressure balance and pressure balance under test,

$m_{et,i}$, m_i are the masses of the weights on the standard pressure balance and pressure balance under test for the i-th equilibrium,

$\varrho_{et,i}$, ϱ_i are the densities of the weights on the standard pressure balance and pressure balance under test for the i-th equilibrium,

ϱ_F is the density of the pressure medium,

H is the vertical distance between the datum levels of the pistons of the standard pressure balance and pressure balance under test, determined by means of their reference levels (H is positive when the piston datum level of the standard pressure balance is higher than that of the pressure balance under test),

ϱ_b is the density of ambient air during the test,

g is the standard acceleration due to gravity,

γ is the surface tension of the pressure medium used for testing, and

C_{et}, C are the circumferences of the pistons of the standard pressure balance and pressure balance under test.

Note: The expression $\gamma \cdot C/g$ and $\gamma \cdot C_{et}/g$ in the equation (3) are negligible in many cases.

A.5.5.3.2 The auxiliary coefficients Φ_i and Λ_i in the equation (3) are corrections for the variations of the effective area in relation to temperature and pressure respectively:

$$\Phi_i = (\alpha_{1,et} + \alpha_{2,et}) \cdot (t_{et} - t_r) - (\alpha_1 + \alpha_2) \cdot (t - t_r) \quad (4)$$

$$\Lambda_i = (\lambda_{et} - \lambda) \cdot p_i \quad (5)$$

where

$\alpha_{1,et}$, α_1	are the coefficients of thermal linear expansion of the materials of the pistons of the standard pressure balance and pressure balance under test,
$\alpha_{2,et}$, α_2	are the coefficients of thermal linear expansion of the materials of the cylinders of the standard pressure balance and pressure balance under test,
t_{et}, t	are the temperatures of the standard pressure balance and pressure balance under test,
t_r	is the reference temperature,
λ_{et}, λ	are the coefficients of pressure deformation of the piston-cylinder assemblies of the standard pressure balance and pressure balance under test, and
p_i	is the value of the measured pressure at the i-th equilibrium.

A.5.5.3.3 For verification, the values of the pressure deformation coefficients shall be taken from the manufacturer's specifications or from the pattern approval certificates. For pattern evaluation, however, they shall be determined experimentally or by calculation according to Annex C.

A.5.5.3.4 From the individual values of effective area $A_{i,o}$ according to the equation (3), one calculates:

a) the effective area A_o

$$A_o = \frac{1}{n} \cdot \Sigma A_{i,o} \quad (6)$$

where n is the number of measurements,

b) the estimated standard deviation of the mean value σ_A

$$\sigma_A = \left[\frac{\Sigma(A_{i,o} - A_o)^2}{n-1} \right]^{1/2} \quad (7)$$

A.5.5.3.5 The value of the effective area A_o shall be compared with the value given by the manufacturer. If the two values differ by more than 50 % of the maximum permissible error of the pressure balance according to 4.4, the value determined during the test shall be considered as the effective area of the pressure balance and shall be stated in the certificate of the pressure balance.

A.5.5.3.6 The uncertainty of the effective area shall be determined as follows:

a) if the effective area given by the manufacturer is maintained, the uncertainty is the sum of the following two values:

- uncertainty determinated from the difference between the effective area given by the manufacturer and the effective area determined during the test, and
- uncertainty of the determination of the effective area during the test;

b) if the effective area determined during the test is used, the uncertainty is that of the determination of this area during the test.

A.5.6 Masses of the piston with weight carrier and those of the weights

A.5.6.1 When appropriate, the required values of the masses of the piston with weight carrier and those of the weights shall be calculated according to Annex B, using the pressure balance effective area A_o determined according to A.5.5.

A.5.6.2 When appropriate, the mass deviation shall be measured by comparing the mass values of the piston with weight carrier and those of the weights (determined in accordance with A.5.4) with the mass values determined in accordance with A.5.6.1.

A.5.6.3 The uncertainty of mass shall be determined as follows:

a) if nominal values are used, it is the sum of the uncertainty of the adjustment of weights and that of the mass determination during the test;
b) if values determined during the test are used, it is equal to the uncertainty of the mass determination.

A.5.6.4 The relative uncertainty component of pressure measurements due to uncertainty of mass is numerically equal to the relative value of the mass uncertainty.

A.5.7 Pressure deformation coefficient value of piston-cylinder assembly

A.5.7.1 The pressure deformation coefficient of the piston-cylinder assembly shall be determined according to the method described in C.2 or by using any other comparable method.

A.5.7.2 The pressure deformation coefficient value shall be compared with the value given by the manufacturer. The difference between these values shall not exceed 10 %. Otherwise, the value determined during the test shall be used.

A.5.8 Total uncertainty

The total uncertainty of the pressure balance, expressed as a percentage of the measured pressure, is the root-sum-of squares of the following three components:

- effective area uncertainty, expressed as a percentage (A.5.5.3)
- mass uncertainty, expressed as a percentage (A.5.6.3)
- 10 % as a reserve for other uncertainties due to influence quantities (4.5.1.c).

ANNEX B

CALCULATION OF THE REQUIRED MASS OF WEIGHTS
(Informative)

When appropriate, the required mass values of individual weights of the weight-series of a pressure balance should be calculated from the value of the effective area determined according to A.5.5.3. If it is not necessary to consider the dependence of the effective area A with the pressure p, equation (8) applies. If it is necessary to consider this dependence, then the calculation is carried out according to equation (9).

B.1 Calculation without dependency $A = \mathrm{f}(p)$

The piston with weight carrier may create either partially or totally the pressure corresponding to the lower limit of the measuring range. The mass value for the i-th weight of the set is calculated according to the following equation:

$$m_\mathrm{i} = \frac{A_\mathrm{o} \cdot p_\mathrm{i}}{g} \cdot \left(1 + \frac{\varrho_\mathrm{b}}{\varrho_\mathrm{m}}\right) \tag{8}$$

where

m_i is the required mass value of the i-th weight,
p_i is the pressure produced by the i-th weight at reference temperature and under standard gravity,
A_o is the effective area of the pressure balance under zero pressure and at reference temperature,
g is the standard acceleration due to gravity,
ϱ_b is the density of ambient air during the test, and
ϱ_m is the density of the weight material.

B.2 Calculation with dependency $A = \mathrm{f}(p)$

In this case, the value of the mass of the weights depends on the order in which individual weights are loaded onto each other; this order shall be marked on the weights (j). The piston with weight carrier may create either partially or totally the pressure corresponding to the lower limit of the measuring range. The j-th weight value to be loaded on the weight carrier is calculated according to the folowing equation:

$$m_\mathrm{j} = \frac{A_\mathrm{o} \cdot p_\mathrm{j}}{g} \cdot \left(1 + \frac{\varrho_\mathrm{b}}{\varrho_\mathrm{m}}\right) \cdot \left[1 + (2\mathrm{j} - 1) \cdot \lambda \cdot p_\mathrm{j}\right] \tag{9}$$

where

m_j is the mass of the weight to be loaded as j-th in the sequence,
p_j is the pressure produced by the weight loaded as j-th in the sequence at reference temperature and under standard gravity,
A_o is the effective area of the instrument under zero pressure and at reference temperature,
g is the standard acceleration due to gravity,
ϱ_b is the density of the ambient air,
ϱ_m is the density of the weight material, and
λ is the pressure deformation coefficient of the piston-cylinder assembly.

ANNEX C

DETERMINATION OF THE PRESSURE DEFORMATION COEFFICIENT OF THE PISTON-CYLINDER ASSEMBLY

(Informative)

C.1 Methods of determination

The pressure deformation coefficient of the piston-cylinder assembly, λ, is mainly determined by an experimental method of comparison with a standard pressure balance. For pressure balances of a simple-type piston and cylinder, it is possible to determine this coefficient by calculation on the basis of the laws of elasticity and known physical constants of the piston-cylinder assembly material(s).

C.2 Determination of λ by comparison with a standard pressure balance

C.2.1 Principle

The principle of the experimental determination of the deformation coefficient of the piston-cylinder assembly is based on the determination of the relation between the effective area and the measured pressure. It is possible to determine λ or the difference $\lambda_{et} - \lambda$, where λ_{et} is the pressure deformation coefficient of the piston-cylinder assembly of the standard pressure balance.

C.2.2 Direct determination of λ

C.2.2.1 The dependence of the effective area with the measured pressure is given by the following equation:

$$A = A_o \cdot (1 + \lambda \cdot p) \tag{10}$$

where

- A is the effective area of the piston-cylinder assembly of an instrument under the pressure p, at the reference temperature t_r,
- A_o is the effective area of the piston-cylinder assembly of an instrument under zero pressure and at the reference temperature t_r, and
- λ is the pressure deformation coefficient of the instrument's piston-cylinder assembly.

C.2.2.2 The effective area of the piston-cylinder assembly of the pressure balance under test at a given pressure but whitout the correction for Λ, when compared with the standard pressure balance, is calculated from the following equation, derived from equation (3):

$$A_i = \frac{\left[m \cdot \left(1 - \frac{\varrho_b}{\varrho}\right) + m_i \cdot \left(1 - \frac{\varrho_b}{\varrho_i}\right) + \frac{\gamma \cdot C}{g} \right] \cdot A_{et} \cdot (1 + \Phi_i + \lambda_{et} \cdot p_i)}{m_{et} \cdot \left(1 - \frac{\varrho_b}{\varrho_{et}}\right) + m_{et,i} \cdot \left(1 - \frac{\varrho_b}{\varrho_{et,i}}\right) + (\varrho_F - \varrho_b) \cdot A_{et} \cdot H + \frac{\gamma \cdot C_{et}}{g}} \tag{11}$$

where

- A_i is the effective area of the pressure balance under test, at reference temperature, for the i-th equilibrium,
- A_{et} is the effective area of the standard pressure balance, under zero pressure and at reference temperature,

m_{et}, m are the masses of the pistons and weight carriers of the standard pressure balance and pressure balance under test,

ϱ_{et}, ϱ are the densities of the pistons and weight carriers of the standard pressure balance and pressure balance under test,

$m_{et,i}$, m_i are the masses of the weights on the standard pressure balance and pressure balance under test for the i-th equilibrium,

ϱ_{et}, ϱ_i are the densities of the weights on the standard pressure balance and pressure balance under test for the i-th equilibrium,

ϱ_F is the density of the pressure medium,

H is the vertical distance between the datum levels of the pistons of the standard pressure balance and pressure balance under test, determined by means of their reference levels (H is positive when the piston datum level of the standard pressure balance is higher than that of the pressure balance under test),

ϱ_b is the density of ambient air during the test,

γ is the surface tension of the pressure medium used for testing,

g is the standard acceleration due to gravity,

C_{et}, C are the circumferences of the pistons of the standard pressure balance and pressure balance under test, and

λ_{et} is the pressure deformation coefficient of the piston-cylinder assembly of the standard pressure balance.

C.2.2.3 The pressure deformation coefficient of the piston-cylinder assembly may be calculated from the values, A_i, of the instrument's effective areas for individual pressure points, using the method of the least squares, and equation (10), according to the following equation:

$$\lambda = \frac{n \sum_1^n A_i \cdot P_i - \sum_1^n A_i \cdot \sum_1^n p_i}{\sum_1^n A_i \cdot \sum_1^n p_i^2 - \sum_1^n p_i \cdot \sum_1^n A_i \cdot p_i} \qquad (12)$$

where n is the number of pressure values measured.

C.2.2.4 The calculation of the pressure deformation coefficient according to C.2.2.3 may be replaced by a linear regression of the dependency of the effective areas A_i with the measured pressure p_i at individual measured points, the determination of the coefficient for a linear dependency $A_i = \mathrm{k} \cdot p_i$, and the calculation of the coefficient λ using equation (10).

C.2.3 Differential determination of λ

C.2.3.1 Application of equation (10) to both the standard pressure balance and the pressure balance under test gives:

$$\mathrm{R_i} = \mathrm{R_o} \cdot [1 + (\lambda_{et} - \lambda) \cdot p_i] \qquad (13)$$

where

R is the ratio of the effective areas of the piston-cylinder assembly of the standard instrument and instrument under test at a pressure p,

$\mathrm{R_o}$ is the ratio of the effective areas of the piston-cylinder assembly of the standard instrument and instrument under test at zero pressure, and

λ_{et}, λ are the pressure deformation coefficients of the standard instrument and instrument under test.

C.2.3.2 The difference between the pressure deformation coefficients of the standard pressure balance and the pressure balance under test may be calculated from the following equation:

$$\lambda_{et} - \lambda = \frac{\mathrm{R/R_o} - 1}{p} \qquad (14)$$

C.3 Calculation of λ

C.3.1 The pressure deformation coefficient of the piston-cylinder assembly of a pressure balance with a simple-type piston in the cylinder with no re-entry pressure is calculated according to the following equation:

$$\lambda = \frac{1}{2E_2} \cdot \left[\frac{\left(\frac{r}{b}\right)^2 + 1}{\left(\frac{r}{b}\right)^2 - 1} + \mu_2 \right] - \frac{1}{2E_1} \cdot (1 - 3\mu_1) \qquad (15)$$

If the piston and cylinder are of the same material, the coefficient is calculated according to the following equation:

$$\lambda = \frac{1}{E} \cdot \left[\frac{1}{\left(\frac{r}{b}\right)^2 - 1} + 2\mu \right] \qquad (16)$$

C.3.2 The pressure deformation coefficient of the piston-cylinder assembly of a pressure balance with a simple-type piston in the cylinder with re-entry pressure on the full exterior surface of the cylinder and end loading, is calculated according to the following equation:

$$\lambda = -\frac{1}{2E_2} \cdot \left[\frac{3\left(\frac{r}{b}\right)^2 - 1}{\left(\frac{r}{b}\right)^2 - 1} - 3\mu_2 \right] - \frac{1}{2E_1} \cdot (1 - 3\mu_1) \qquad (17)$$

If the piston and cylinder are of the same material, the coefficient is calculated according to the following equation:

$$\lambda = -\frac{1}{E} \cdot \left[\frac{2\left(\frac{r}{b}\right)^2 - 1}{\left(\frac{r}{b}\right)^2 - 1} - 3\mu \right] \qquad (18)$$

The symbols in the equations (14–18) have the following meanings:

E_1 is the elasticity modulus of the piston material,
E_2 is the elasticity modulus of the cylinder material,
μ_1 is the Poisson's ratio for the piston material,
μ_2 is the Poisson's ratio for the cylinder material,
r is the outside radius of the cylinder, and
b is the radius of the piston.

This calculation is not applicable to more complicated shapes of piston and cylinder.

ANNEX D

TEST REPORT FORMAT

Note: This Annex is informative with regard to implementation of this Recommendation in national regulations; however, use of the test report format is mandatory for the application of the Recommendation within the OIML Certificate System.

A test report intended for use in the OIML Certificate System or for other purposes shall include the following information.

D.1 Name and address of the testing laboratory(ies)

D.2 Reference to this Recommendation (number and year of edition)

D.3 General information on the pressure balance under test:

- Application No.:
- Manufacturer:
- Accuracy class:
- Pattern designation:
- Measuring range:

D.4 Test of sensitivity of the device for monitoring the piston position (5.3, A.4.2)

Measurement number	Device data for monitoring piston	Cathetometer data (or equivalent instrument)	Difference
1			
2			
3			

Pass ______________ Fail ______________

Comments: ____

____

D.5 Test for the levelling and indicating device (5.4, A.4.3)

Measurement number	Angle of piston rotation from initial position	Angular deviation from vertical
1	0 °	
2	90 °	
3	180 °	
4	270 °	
5	0 °	

Pass ______________ Fail ______________

Comments: ____

____

D.6 Test of perpendicularity of piston axis and weight carrier (5.5, A.4.4)

Level position	Deviation from zero position	Difference of the deviations in A and B directions
Direction A		
Direction B		

Pass ______________ Fail ______________

Comments: ____

____

D.7 Test of leak-tightness (5.8, A.4.5)

Time	Piston fall value
1	
2	
3	
4	
5	

Pass ______________ Fail ______________

Comments: ____

____

D.8 Test of free rotation time of the piston (4.6, A.5.1)

Measurement number	Initial rotation rate	Temperature	Time until piston stops
1			
2			
3			

Pass ______________ Fail ______________

Comments: ____

____

D.9 Test of rate of fall of the piston (4.7, A.5.2)

Measurement number	Fall distance	Temperature	Time	Fall rate
1				
2				
3				

Pass ______________ Fail ______________

Comments: ____

____

D.10 Determination of the mass of the piston, weight carrier and weights (A.5.4, A.5.6, Annex B)

	Nominal mass	True mass
Piston		
Carrier		
Weight 1		
Weight 2		

Pass ______________ Fail ______________

Comments: ____

____

D.11 Determination of the effective area (A.5.5)

Measurement number	Pressure point	Standard weight	Tested weight	Temperature	Effective area $A_{i,o}$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
				A_o =	
				σ_A =	

Comments: ______________________________

D.12 Determination of pressure deformation coefficient by comparison with a standard pressure balance (Annex C)

Measurement number	Pressure point	Standard weight	Tested weight	Temperature	Effective area $A_{i,o}$	Effective area A_i	Deformation coefficient
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Comments: ____________________

____

D.13 Deviation of the masses of the weights from required values (A.5.4, A.5.6, Annex B)

Weight number	True mass	Required mass	Deviation true – required
1			
2			
3			

Pass ______________ Fail ______________

Comments: ____

____

D.14 Test for discrimination threshold (A.5.3)

Measurement number	Weight added (%)	Change in the piston rate of fall or in differential pressure indication *(yes or no)*
1		
2		
3		
4		
5		

Pass ______________ Fail ______________

Comments: ____

____

D.15 Total uncertainty of the pressure balance: _________________

D.16 Brief statement of the conclusions as to whether the instrument sample(s) tested meet the requirements of this Recommendation for the specified accuracy class

D.17 Signature of the responsible person(s), date signed, and unique test report number

Printed in France

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