

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE



INTERNATIONAL RECOMMENDATION

Pressure gauges and vacuum gauges with elastic sensing elements
(standard instruments)

Manomètres et vacuomètres à élément récepteur élastique (instruments étalons)

OIML R 109

Edition 1993 (E)

CONTENTS

Foreword	3
1 Scope	4
2 Terminology	4
3 Unit of measurement of pressure	5
4 Metrological requirements	5
4.1 Main parameters	5
4.2 Metrological characteristics	5
5 Technical requirements	7
5.1 Pointer	7
5.2 Scale	7
5.3 Inscriptions and designations	7
6 Metrological controls	8
6.1 Types of metrological controls	8
6.2 Pattern evaluation and approval	8
6.3 Verification method	9

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
Telex: 234 444 SVP SERV F ATTN OIML

*
* *

This publication - reference OIML R 109, edition 1993 (E) - was developed by the OIML working groups SP 11-Sr 4 "Pressure gauges with elastic sensing elements" and SP 11 "Measurement of pressure". It was sanctioned by the International Conference of Legal Metrology in 1992.

PRESSURE GAUGES and VACUUM GAUGES with ELASTIC SENSING ELEMENTS (standard instruments)

1 Scope

This Recommendation applies to pressure gauges and vacuum gauges (standard instruments) with elastic sensing elements.

The application of this Recommendation is limited to instruments in which the elastic deformation of the sensing element is mechanically transmitted to the indicating device using a pointer and a dial graduated in legal units of pressure, and in which the upper limit of the measuring range is between 0.06 MPa and 250 MPa for pressure gauges, and between – 0.1 MPa and zero for vacuum gauges.

2 Terminology

The terminology used in this Recommendation conforms to the “International Vocabulary of Basic and General Terms in Metrology” (VIM - 1984 edition) and the “Vocabulary of Legal Metrology” (VML - 1978 edition). In addition, for the purposes of this Recommendation, the following definitions apply.

2.1 Gauge pressure

A pressure greater than ambient pressure.

2.2 Vacuum

A pressure less than ambient pressure.

2.3 Ambient pressure

The pressure of the environment of the instrument at the place and time of the measurements.

The ambient pressure may be atmospheric pressure, or it may have a value near to that of the atmospheric pressure when measurements are carried out in an enclosed, sealed space.

2.4 Normal limit of the measuring range

The upper limit of the part of the measuring range acceptable for permanent operation of the instrument in service.

2.5 Absolute error of measurement

The difference between the indication of the instrument to be verified and that of the standard instrument for the same pressure.

2.6 Hysteresis error

The difference between the indications of the instrument when the same pressure (except pressures at the lower and upper limits of the measuring range) is reached by increasing or decreasing the pressure.

3 Unit of measurement of pressure

3.1 The unit of measurement of pressure is the pascal, Pa.

3.2 Scales of pressure gauges and vacuum gauges shall be graduated in Pa or its multiples: kPa, MPa and GPa, according to the rules of the International System of Units (SI).

The bar and its submultiples, especially the mbar, may be used insofar as they are admitted by national regulations and until there is an international decision on their use.

4 Metrological requirements

4.1 Main parameters

4.1.1 Measuring range (upper limit and normal limit)

4.1.1.1 The upper limit of the measuring range shall be chosen from one of the following two series:

1×10^n 1.6×10^n 2.5×10^n 4×10^n 6×10^n

1×10^n 2×10^n 5×10^n

units of pressure

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

4.1.1.2 The normal limit of the measuring range shall be equal to the upper limit of the measuring range.

4.1.2 Accuracy class

The accuracy class of the instrument shall be chosen from one of the following two series:

0.06 0.1 0.16 (0.15) 0.25 0.4 0.6

0.1 0.2 0.5

The number designating the accuracy class is also the maximum permissible error expressed as a percentage of the upper limit of the measuring range.

4.1.3 Working temperature range

The working temperature range shall be from 10 °C to 35 °C.

4.2 Metrological characteristics

4.2.1 Error of measurement and hysteresis error

4.2.1.1 The maximum permissible intrinsic error including hysteresis under the conditions specified in 6.3.5.1, is:

a) $\pm 0.8 A$, for new or repaired instruments,

b) $\pm A$, for instruments in service,

where A is equal to the number designating the accuracy class (4.1.2).

4.2.1.2 The hysteresis error shall not exceed the absolute value of the maximum permissible error specified in 4.2.1.1.

4.2.1.3 The displacement of the pointer caused by friction (see 6.3.8.2) shall not exceed one-half of the absolute value of the maximum permissible error.

4.2.1.4 The displacement of the pointer within the scale at increasing and decreasing pressures shall be smooth and without visible sticking and jumping.

4.2.2 Temperature deviation

If the ambient temperature differs from the reference temperature as specified in 6.3.5.1, the temperature correction shall be applied to the indications of the instruments.

The value of the temperature correction is determined from the formula:

$$\Delta_t = \alpha \times (t_1 - t_2) \times P$$

where:

α is the temperature coefficient defined by national regulations, in $^{\circ}\text{C}^{-1}$

t_1 is the reference (6.3.5.1) or nominal (6.3.5.4) temperature, in $^{\circ}\text{C}$

t_2 is the ambient air temperature (4.1.3), in $^{\circ}\text{C}$

P is the measured pressure, in Pa

4.2.3 Stability of indications

4.2.3.1 Instruments shall be capable of withstanding a pressure exceeding the upper limit of the measuring range, L, by a value ΔP as shown in Table 1, for 15 minutes.

Table 1

Upper limit of the measuring range L (MPa)	ΔP as % of the upper limit of the measuring range, L for accuracy classes				
	0.06	0.1	0.16 (0.15)	0.25	0.4 0.6
		0.1	0.2		0.5
$L \leq 10$			25		25
$10 < L \leq 25$			15		15
$25 < L \leq 60$			10		15
$60 < L \leq 160$			5		10
$160 < L \leq 250$			5		5

4.2.3.2 Instruments shall be capable of withstanding a pressure varying continuously close to sine law, within 25 % to 30 % up to 65 % to 75 % of the upper limit of the measuring range, with a frequency not exceeding 1 Hz and for a total number of cycles indicated in Table 2.

Table 2

Upper limit of the measuring range L (MPa)	Number of cycles for accuracy classes				
	0.06	0.1	0.16 (0.15)	0.25	0.4 0.6
		0.1	0.2		0.5
$0.06 < L \leq 10$			10 000		15 000
$10 < L \leq 60$			10 000		10 000
$60 < L \leq 160$			5 000		5 000
$160 < L \leq 250$			5 000		5 000

4.2.3.3 When transported, instruments shall be packed so as to ensure that their metrological characteristics are maintained. When it is necessary to check the effect of transport conditions, the packed instruments shall be submitted to:

- a) an ambient air temperature of $-20\text{ }^{\circ}\text{C}$ (or, in special cases, $-50\text{ }^{\circ}\text{C}$) and $+50\text{ }^{\circ}\text{C}$ for six hours at each temperature,
- b) shaking with an acceleration of 30 m/s^2 and a frequency of 80 to 120 shocks per minute for two hours.

5 Technical requirements

5.1 Pointer

5.1.1 The tip of the pointer shall cover $3/10$ to $7/10$ of the length of the shortest scale mark.

5.1.2 The tip of the pointer at the reading point shall be of a form such that the parallax error does not exceed $1/10$ of the scale interval.

5.1.3 The width of the tip of the pointer shall not be greater than the width of the scale marks.

5.1.4 The distance between the scale and the pointer shall not exceed the distance between two neighbouring scale marks.

5.1.5 Instruments may be fitted with a zero-setting device that alters the position of the pointer with respect to the scale.

5.2 Scale

5.2.1 The scale interval shall be close to the value of the maximum permissible error and shall be chosen from the series:

$$1 \times 10^n \quad 2 \times 10^n \quad 5 \times 10^n \quad \text{units of pressure}$$

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

5.2.2 The scale spacing shall not be less than 1 mm.

5.2.3 The thickness of the scale marks shall not exceed $1/5$ of the smallest scale spacing.

For linear scales, the scale spacing shall be as constant as possible; the greatest scale spacing shall not exceed by more than $1/5$ the smallest scale spacing on the same scale.

5.3 Inscriptions and designations

5.3.1 The instrument dial shall bear the following inscriptions:

- the symbol of the unit of measurement
- on the scales of vacuum gauges, the symbol for vacuum “–” (minus sign)
- the accuracy class designation
- any other symbols or inscriptions in connection with the use of the instrument

5.3.2 The dial or the instrument casing shall bear the following inscriptions:

- the manufacturer's trademark or name
- the serial number and year of manufacture

6 Metrological controls

6.1 Types of metrological controls

When, in any country, standard manometers and vacuummeters are subject to State metrological controls for certain applications, these controls shall include, according to the internal legislation of that country, either all of some of the following:

- pattern evaluation
- initial verification
- subsequent or periodic verifications

6.2 Pattern evaluation and approval

6.2.1 Any new or modified design of instruments intended for applications that are subject to metrological controls shall first be subjected to pattern evaluation by an appropriate authority.

6.2.2 Patterns shall be evaluated in order to determine their compliance with the relevant requirements of this Recommendation.

The tests shall include:

- 1) examination of the instruments to ensure that they are satisfactorily constructed and that they comply, whenever appropriate, with the requirements in 5;
- 2) evaluation of the metrological characteristics of the instruments in order to ensure that the errors do not exceed the maximum values permitted for the intended accuracy class, as specified in 4.2.1.

6.2.3 Pattern evaluation shall be carried out under the conditions specified in 6.3.5.

6.2.4 If the results of the tests are satisfactory, the testing authority shall, according to national requirements:

- 1) define procedures for the initial and subsequent verifications of instruments of the tested pattern;
- 2) fix the maximum time interval between verifications; when making the decision, consideration should be given to the stringency of the application, the expected frequency of use, the housing of the instrument and the extent to which it will be transported;
- 3) issue a pattern approval certificate containing the following information:
 - the name of the testing authority
 - the manufacturer's name
 - the pattern designation number, name or code
 - the accuracy class of the pattern
 - a brief description of the instrument and its function
 - the traceability of the standards used in the evaluation
 - any special limitations on the use of the instrument
 - the procedures for verification
 - the maximum time interval between verifications.

6.3 Verification method

6.3.1 The instrument shall be verified initially and subsequently by a qualified and accredited authority and according to national requirements.

6.3.2 If the instrument is repaired, it shall be re-verified before use.

6.3.3 Verification operations

Verification includes the following operations:

- a visual inspection,
- a preliminary check, and
- the determination of metrological characteristics according to 4.2.1.1 and 4.2.1.3.

6.3.4 General requirements for verification equipment

6.3.4.1 The upper limit of the measuring range of the verification equipment shall not be less than the upper limit of the measuring range of the instrument to be verified, and the lower limit shall not exceed 1/10 of the lower limit of the measuring range of the instrument to be verified.

6.3.4.2 The errors of the equipment used for the verification of instruments shall not exceed 1/4 of the maximum permissible error of the instruments to be verified.

6.3.4.3 A separator shall be used when the pressure medium in the instrument to be verified differs from that in the standard instrument; this separator shall not cause any additional error greater than 1/10 of the maximum permissible error of the instrument to be verified.

6.3.4.4 The end of the coupling of the standard instrument and that of the instrument to be verified shall be at the same level, or the pressure due to the column of working media used shall be taken into account. The error due to the difference in level shall always be less than 1/10 of the maximum permissible error of the instrument to be verified.

6.3.4.5 The verification installation shall permit the pressure of the medium used to be increased or decreased continuously.

6.3.4.6 The verification installation shall permit both the instruments to be verified and the standard instrument to be set up in their normal operating positions, according to the manufacturer's specifications.

6.3.5 Verification conditions

6.3.5.1 The instruments shall comply with the requirements in 4.2.1.1 under the following reference conditions:

- 1) the instruments shall be installed in their normal operating position;
- 2) the pressure variation shall be continuous and slow;
- 3) the temperatures of the instrument to be verified, of the standard instrument, and of ambient air shall be:
20 °C ± 2 °C for instruments of accuracy classes 0.06 0.1 0.16 (0.15) 0.2 0.25
and,
20 °C ± 5 °C for instruments of accuracy classes 0.4 0.5 0.6.

Deviations from these temperatures at the time of measurements shall not cause a variation of indications greater than 1/5 of the maximum permissible error of the instruments;

- 4) the relative humidity shall not exceed 80 %;
- 5) there shall be no vibrations or shocks liable to produce an oscillation of the pointer with an amplitude greater than 1/10 of the smallest scale spacing;
- 6) except when otherwise specified on the instrument to be verified or in the accompanying technical documentation, the medium used to transmit the pressure at the time of verification shall be:
 - an inert or a neutral gas for instruments of accuracy classes 0.4 0.5 0.6 with the upper limit of the measuring range not exceeding 0.4 MPa and for instruments of accuracy classes 0.06 0.1 0.16 (0.15) 0.2 0.25 with the upper limit of the measuring range not exceeding 1.6 MPa;
 - a noncorrosive liquid for other types of instruments;
 - however, for instruments for which the change-over from gas to liquid, and vice versa, does not cause a change in indication greater than 1/5 of the maximum permissible error, any medium (gas or liquid) may be used for the verification;
- 7) the pointer of an instrument provided with a zero-setting device shall be placed on the zero line in the normal operating position at the ambient pressure;
- 8) the readings shall be accomplished after slightly tapping the instrument case.

6.3.5.2 Before beginning the verification procedure, the instrument to be verified and the standard instrument shall be kept at the ambient air temperature specified in 6.3.5.1 for at least six hours.

6.3.5.3 The ambient air shall comply with any health and safety regulations of the workplace; it shall not contain dust or impurities that might corrode any part of the instrument with which it may come into contact.

6.3.5.4 If an instrument has been graduated under nominal conditions other than the reference conditions specified in 6.3.5.1, it shall be checked for conformity with the requirements in 4.2.1.1 and 4.2.1.2 under those nominal conditions, when the difference between the nominal conditions and the reference conditions of 6.3.5.1 causes a variation of indication exceeding 1/5 of the maximum permissible error.

6.3.6 Verification procedure

6.3.6.1 Visual inspection

6.3.6.1.1 The instruments to be verified shall conform to an approved pattern when there is a national regulation for pattern approval.

6.3.6.1.2 The instruments to be verified shall have no visible traces of corrosion, dents, dust or dirt on the case. The thread on the coupling and the seal shall be in good condition; the protective window in front of the dial shall be without scratches and colour changes or other defects that may impair the reading of the indications.

6.3.6.1.3 The forms of the tip of the pointer and the graduations and inscriptions on the dial or the instrument case shall comply with the requirements specified in 4.2.

6.3.6.1.4 The instruments presented for periodic verification shall bear the mark of the previous verification or be accompanied by the previous verification certificate. The periodicity of verification shall be specified in national regulations.

6.3.6.2 Preliminary check

6.3.6.2.1 The leak-tightness of the instrument to be verified shall be checked after it is connected to the verification system. For this purpose, the instrument to be verified is pressurized to the upper limit of its measuring range. The instrument is then disconnected and left to rest for three minutes; it is considered to be leak-tight if, during the next two minutes, the pressure change does not exceed 1 % of the upper limit of the measuring range of the instrument.

6.3.6.2.2 The movement of the instrument pointer is checked with pressures that increase and then decrease continuously. The pointer shall move smoothly and without visible sticking and jumps resulting in variations greater than one-half of the absolute value of the maximum permissible error.

6.3.6.2.3 The pointer of the instrument not supplied with a zero-setting device shall rest at the zero scale mark. Any deviation from zero shall not exceed an absolute value of the maximum permissible error after slight tapping by hand on the instrument case in its working position and at the ambient pressure.

6.3.6.2.4 The zero-setting device, if provided, should guarantee movements of the needle not less than the absolute value of the maximum permissible error.

6.3.7 Determination of metrological characteristics

6.3.7.1 Determination of the measurement errors and hysteresis errors

The readings of the instrument to be verified shall be taken after slight tapping on the instrument case by hand, for at least eight pressure values evenly distributed throughout the measuring range, including zero and the upper limit of the measuring range.

For vacuum gauges with the limits of the measuring range of -0.1 MPa and zero, it is permitted to use from eight to ten dial points, depending on ambient pressure during the verification.

The readings shall be taken for pressures that increase and then decrease continuously after a rest period of at least five minutes at the upper limit of the measuring range.

For conformity with 6.3.7.1 and 6.3.7.2, the instruments of accuracy classes 0.06 0.1 0.16 (0.15) 0.2 shall be checked in three measurement series and the instruments of accuracy classes 0.25 0.4 0.5 0.6 in two measurement series and with at least a five-minute interval between each series.

The absolute error of the instrument to be verified shall be determined as the difference between the indication of the instrument to be verified and that of the standard instrument, for the same pressure.

The absolute error of the instrument to be verified shall not exceed the maximum permissible error specified in 4.2.1.1.

The hysteresis error of the instrument to be verified shall be determined as the absolute value of the difference between the indications of the instrument when the same pressure (except pressures at the lower and upper limits of the measuring range) is reached by increasing or decreasing the pressure.

6.3.7.2 Evaluation of friction influence

The influence of friction shall be evaluated by the displacement of the pointer simultaneously with the determination of the measurement and hysteresis errors, as specified in 6.3.7.1.

Two readings shall be taken for each pressure value: one directly after obtaining a given pressure value and the other after slight tapping on the case of the instrument.

The difference of indications obtained between these two readings shall not exceed the values specified in 4.2.1.3.

6.3.8 Presentation of verification results

6.3.8.1 The instruments that meet the requirements of this Recommendation shall be declared suitable for use.

6.3.8.2 The instruments that are declared suitable for use shall be provided with a verification mark, or be supplied with a verification certificate.

6.3.8.3 The certificate of verification of an instrument shall, according to national requirements, include the following:

- 1) the name of the approved testing authority
- 2) the name of the owner of the instrument
- 3) the name of the manufacturer
- 4) the designation, number or code of the approved pattern with which it conforms
- 5) the number, date and origin of the pattern approval certificate
- 6) the accuracy class
- 7) a brief description of the instrument
- 8) the serial number of the instrument
- 9) the year of manufacture, if known
- 10) the traceability of the standards used in the verification
- 11) any special limitations for the use of the instrument
- 12) the expiration date of the verification certificate