INTERNATIONAL

RECOMMENDATION

OIML R 53

Edition 1982 (E)

Metrological characteristics of elastic sensing elements used for measurement of pressure

Determination methods

Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression
Méthode de leur détermination

OIML R 53 Edition 1982 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Foreword

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This publication – reference OIML R 53 (E), edition 1982 – which is under the responsibility of TC 10/SC 2 *Pressure gauges with elastic sensing elements*, was sanctionned by the International Conference of Legal Metrology in 1980.

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TERMINOLOGY

Pressure

Gauge or vacuum pressure (see International Recommendations No's 17 and 19) to which the elastic sensing element can be submitted.

Nominal pressure

Maximum pressure specified for the given elastic sensing element [*].

Overload pressure

Pressure greater than nominal pressure, but at which the limit of elastic deformation of the elastic sensing element is not exceeded.

Reference point

That part of the elastic sensing element, whose displacement is converted into an indication of the instrument.

Nominal displacement

Value of the displacement of the reference point, due to the effect of nominal pressure.

Elastic characteristic

Relation between the displacement of the reference point and pressure.

Forward elastic characteristic

Relation between the displacement of the reference point and pressure, when the pressure increases.

Reverse elastic characteristic

Relation between the displacement of the reference point and pressure, when the pressure decreases.

Conventional linear characteristic

Characteristic reflecting the direct proportionality between displacement and pressure, the initial and final points of which coincide with the corresponding points of the forward elastic characteristic.

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[*] The values of nominal pressure must be chosen from the series adopted for the upper limit of the measurement range for pressure gauges which are the subject of the Recommendation No 17.

Hysteresis

Difference between the values of displacement of the reference point for a given value of pressure, obtained for decreasing and increasing pressures.

Non-linearity of elastic characteristic

Difference between the forward elastic characteristic and the conventional linear characteristic.

Sensitivity

Quotient of the increase in value of displacement of the reference point and the corresponding increase in pressure.

Initial position

Position of the reference point at a pressure equal to zero.

Final position

Position of the reference point at a pressure equal to the nominal pressure.

Change of initial position

Displacement of the initial position after the elastic sensing element has been submitted to nominal pressure, to overload pressure, or to another pressure over a certain period of time.

Stability of elastic characteristic

Aptitude of the elastic sensing element to retain a constant elastic characteristic.

Note : The chapter « Terminology » was drafted by the Reporting Secretariat « Pressure gauges with elastic sensing elements » in order to facilitate an unambiguous understanding of this Recommendation.

The terms and definitions contained in this chapter should be considered as provisional. They may be modified when the terminology of pressure measurement is established in a systematic manner, by a Secretariat especially appointed for this purpose.

METROLOGICAL CHARACTERISTICS of ELASTIC SENSING ELEMENTS used for MEASUREMENT of PRESSURE

Determination methods

1. Field of application.

This Recommendation concerns the main metrological characteristics of elastic sensing elements (diaphragms, capsules, bellows, tubes, etc.) and their determination methods [*].

The Recommendation applies to elastic sensing elements [**] which convert the applied pressure into a displacement, and which are designed for use in pressure gauges, vacuum pressure gauges and pressure-vacuum gauges, as described in International Recommendations No's 17 and 19.

The Recommendation does not prescribe statutory requirements for the metrological characteristics of elastic sensing elements. These requirements are specified in national regulations.

2. Main metrological characteristics.

The following metrological characteristics of elastic sensing elements are to be determined :

— nominal displacement,
— non-linearity of elastic characteristic,
— hysteresis,
— sensitivity,
— change of initial position,
— stability of elastic characteristic.

3. Units of measurement.

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

When applying this Recommendation, multiples of the pascal, according to the rules of the International System SI, are authorized, especially the following multiples : kPa, MPa and GPa.

The bar and its sub-multiples and multiples, especially the mbar, are authorized in so far as they are admitted by national regulations, and awaiting an international decision on their use [***].

3.2. Linear displacement may be expressed in millimeters, mm, angular displacement in degrees, °.

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[*] This Recommendation does not prevent the use of other, improved methods.

[**] The term « elastic sensing element » implies a device ready to be fitted to the instrument.

[***] The factors relating certain pressure units, not belonging to the International System, to the pascal, can be found in the International Document No 2.

4. Method for determining the metrological characteristics.

4.1. The metrological characteristics of an elastic sensing element may be determined, with this element :

— either integral with the device to which it belongs, ready to be fitted to the instrument, and manufactured according to national requirements,

— or placed in a special test device, providing compatibility of test results with those which would be obtained using the device to which the element belongs.

4.2. The maximum values of non-linearity and hysteresis, together with the value of nominal displacement, are determined at a temperature of 20 ± 2 °C, according to points 4.2.1. to 4.2.3.

4.2.1. The sensing element is submitted to a pressure which is taken to its nominal value, either in a continuous manner, or in discrete steps.

The number of steps must be sufficient to provide the maximum values of hysteresis and non-linearity, and to enable subsequent determination of sensitivity.

The displacement of the reference point is determined as a function of pressure.

4.2.2. The maximum value of non-linearity is determined over the range of nominal displacement, as being the greatest difference between the forward elastic characteristic and the conventional linear characteristic.

This difference is expressed as a percentage of the nominal displacement.

4.2.3. The maximum value of hysteresis is determined over the range of nominal displacement, as follows.

The elastic sensing element remains at nominal pressure for a period of at least five minutes. It is then progressively unloaded and the displacement of the reference point is measured for the same pressures as those used during measurement with increasing pressure.

The period during which the elastic sensing element remains at intermediate pressures, both for increasing and decreasing pressures, must be as short as possible.

The maximum value of hysteresis is expressed as a percentage of nominal displacement.

Notes :

1) The tests at ambient pressure close to 0.1 MPa, of elastic sensing elements to be used in vacuum gauges and pressure-vacuum gauges having an upper limit of the measurement range of the vacuum pressure of 0.1 MPa, are carried out up to a pressure equal to 1/10 of the ambient air pressure.

2) The number of tests carried out according to point 4.2. must be sufficient to permit accurate determination of the values of hysteresis and non-linearity.

4.3. The sensitivity δ of an elastic sensing element, having a non-linear elastic characteristic, is determined according to points 4.3.1. to 4.3.3.

4.3.1. The increases in values of displacement $\Delta \ell$, corresponding to intervals of pressure Δp, are determined according to the data in point 4.2.1.

4.3.2. The sensitivity of the elastic sensing element, at test pressure, is determined as the quotient of the increase in value of displacement $\Delta \ell$, and the increase of pressure Δp, causing the increase in value of displacement.

For example, in accordance with figure 4 :

$$\delta_1 = \frac{\Delta \ell_1}{\Delta p_1}$$

.....

$$\delta_5 = \frac{\Delta \ell_5}{\Delta p_5}$$

4.3.3. In order to determine the sensitivity of the elastic sensing element at any pressure (not exceeding nominal pressure), a graph of the relation between sensitivity and pressure is plotted according to the data in point 4.3.2.

4.4. The sensitivity δ of an elastic sensing element having a linear elastic characteristic is determined as the quotient of any displacement ℓ (not exceeding nominal displacement) and pressure p causing this displacement (according to the data in point 4.2.1.).

$$\delta = \frac{\ell}{p}$$

4.5. The change of initial position, after application of nominal pressure, is determined at a temperature of 20 ± 2 °C, according to points 4.5.1. to 4.5.3.

4.5.1. The initial position is determined using an appropriate measuring instrument.

4.5.2. The elastic sensing element is submitted to nominal pressure, and this pressure is maintained for 24 hours. Then, the pressure is reduced to zero and the sensing element remains unloaded for one hour.

4.5.3. The change of initial position is measured and expressed as a percentage of nominal displacement.

Note : The tests at ambient pressure close to 0.1 MPa, of elastic sensing elements to be used in vacuum gauges and pressure-vacuum gauges having an upper limit of the measurement range of the vacuum pressure of 0.1 MPa, are carried out up to a pressure equal to 1/10 of the ambient air pressure.

4.6. The change of initial position after application of the overload pressure, is determined at a temperature of 20 ± 2°C, according to points 4.6.1. to 4.6.3.

4.6.1. The initial position is determined. Then, the elastic sensing element is submitted to overload pressure, in accordance with Table 1.

Table 1

Nominal pressure Mpa	Overload pressure as % of nominal pressure
up to 60 included	110
from 60 to 1 000	105

4.6.2. The elastic sensing element remains at the pressure indicated in 4.6.1. for 15 minutes. Then, the pressure is reduced to zero and the sensing element remains unloaded for one hour.

4.6.3. The change of initial position is measured and expressed as a percentage of nominal displacement.

Note : Elastic sensing elements to be used in vacuum gauges are not submitted to the tests described in point 4.6.

4.7. The stability of an elastic sensing element is determined at a temperature of 20 ± 2 °C, according to points 4.7.1. to 4.7.5.

4.7.1. The elastic characteristic (point 4.2.) and the change of initial position after application of nominal pressure (point 4.5.) and of overload pressure (point 4.6.) are determined.

4.7.2. The intial position is determined.Then the sensing element is submitted to a pressure varying continuously with a frequency not exceeding 1 Hz, between the limits and for the number of cycles indicated in Table 2.

Table 2

Nominal pressure MPa	Pressure variation limits as % of nominal pressure	Number of cycles
from 0.05 to 10 included	from 30 to 70	15 000
from 10 to 60 included	from 40 to 60	10 000
from 60 to 160 included	from 40 to 60	5 000
from 160 to 1 000 included	from 40 to 60	1 000

4.7.3. The pressure is reduced to zero, and the elastic sensing element remains unloaded for one hour. The change of initial position is measured.

4.7.4. The elastic characteristic (point 4.2.) and the change of initial position after application of overload pressure (point 4.6.) are again determined.

4.7.5. By comparing the results of both series of tests, before and after application of the cyclic pressure, the stability of the elastic sensing element is determined; this is characterized by the constancy :

— of nominal displacement,
— of the maximum values of non-linearity and hysteresis,
— of the change of initial position.

5. Requirements concerning measuring methods.

5.1. The maximum permissible absolute error for instruments used for measurement of displacement in the determination of hysteresis and of the change of initial position must not exceed 1/4 of the maximum permissible absolute value of hysteresis. When determining non-linearity, this error must not exceed 1/4 of the maximum permissible absolute value of non-linearity.

5.2. The maximum permissible fiducial error for instruments used for measurement of pressure in the determination of hysteresis must not exceed 1/4 of the value of hysteresis expressed as a percentage.

5.3. The error for instruments used for measurement of pressure in the determination of the change of initial position, after application of nominal pressure and overload pressure, must not exceed 1 % of the nominal pressure.

5.4. The error for instruments used for measurement of pressure in cyclic stability tests on elastic sensing elements must not exceed 2.5 % of the nominal pressure.

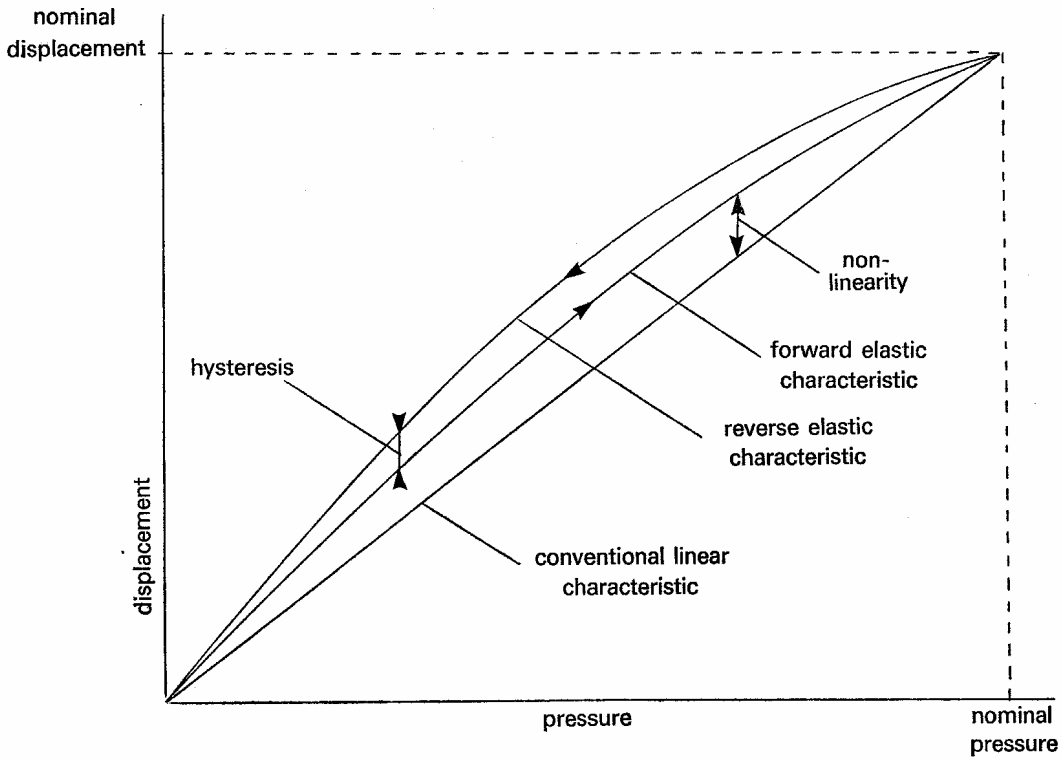

Figure 1
Elastic characteristic without change of the initial and final positions

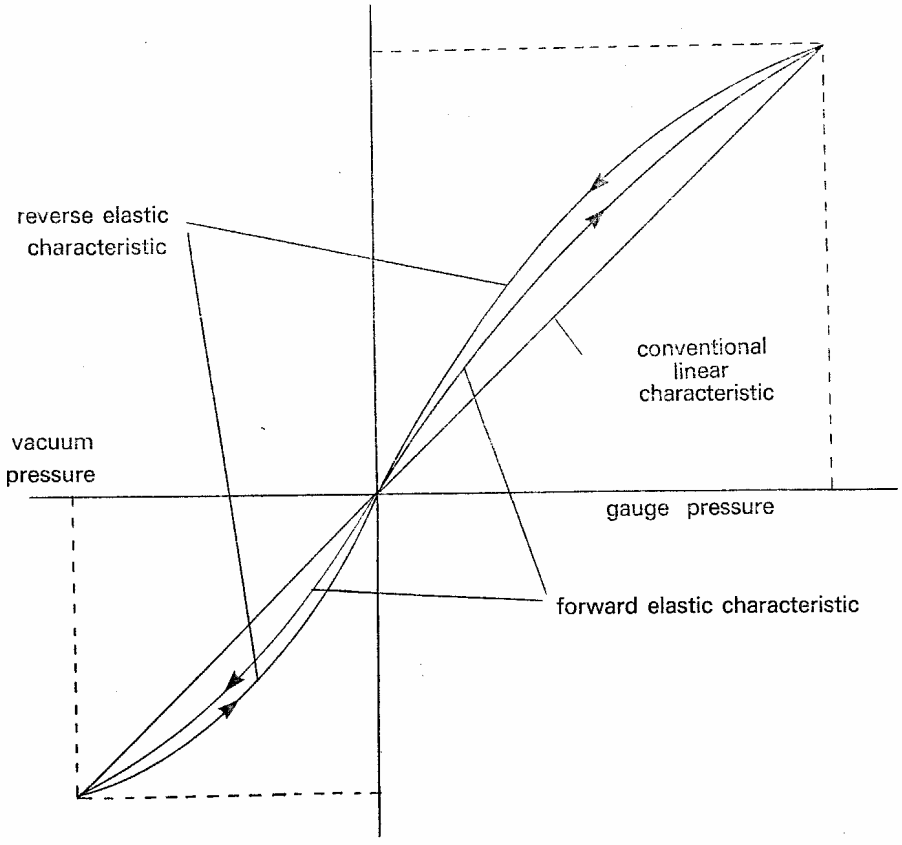

Figure 2
Elastic characteristic of an elastic sensing element for pressure-vacuum gauge, without change of the initial and final positions

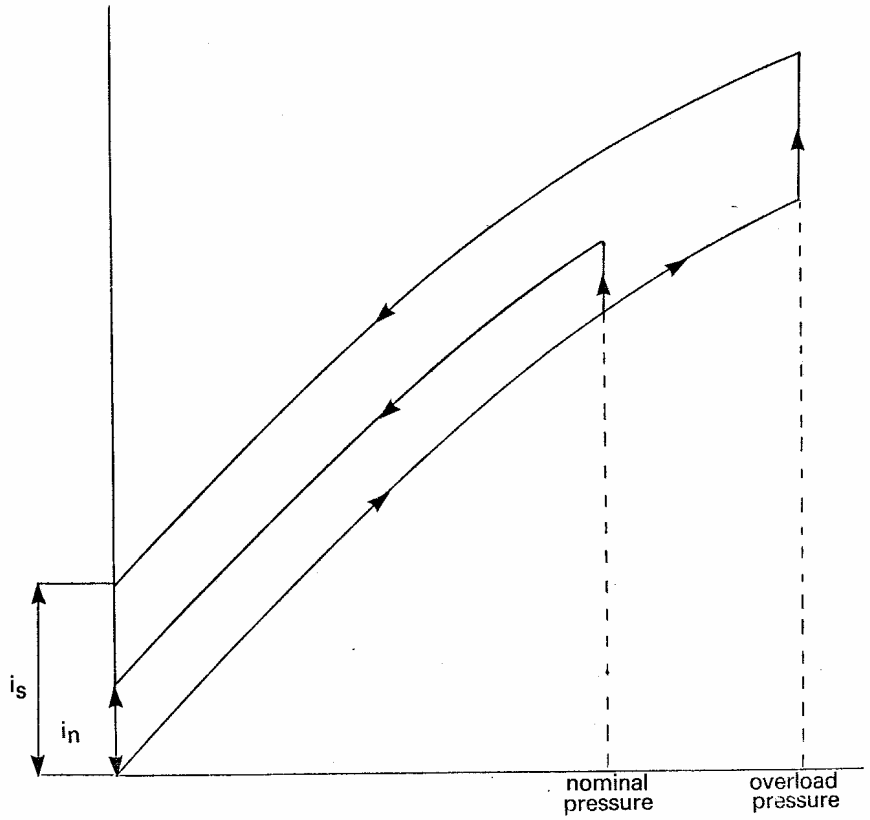

Figure 3

Elastic characteristic with change of the initial position
i_n : after application of the nominal pressure
i_s : after application of the overload pressure

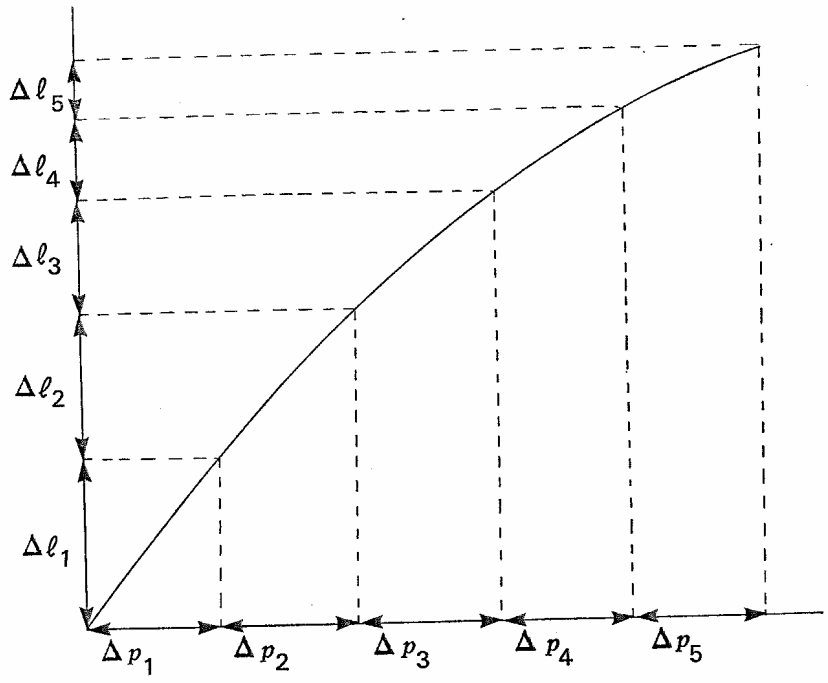

Figure 4

Determination of sensitivity in the case of a non-linear elastic characteristic

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