INTERNATIONAL

RECOMMENDATION

OIML R 34

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Accuracy classes of measuring instruments

Classes de précision des instruments de mesurage

OIML

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Foreword

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The two main categories of OIML publications are:

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

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

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

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

Accuracy classes
of measuring instruments

CHAPTER I

1 General

1.1. Scope

1.1.1. This Recommendation lays down the principles for the classification of measuring instruments according to their accuracy.

1.1.2. The measuring instruments to which this Recommendation applies are :

– material measures,

– measuring instruments,

– measuring transducers,

where these instruments are intended for use in conditions in which errors due to inertia are negligible in relation to the maximum errors laid down for them.

1.1.3. The requirements of this Recommendation are not mandatory for zero indicating instruments, or for equipment especially designed for measuring by multiple reading of the indications and for determining the measurement results as the arithmetic mean of several observations.

The Recommendation need also not apply to measuring instruments intended to reproduce, convert or measure quantities linked simultaneously to several parameters, if different maximum errons have to be fixed for these instruments (eg measurement generators cathode ray oscilloscopes) in accordance with these parameters.

1.2. Principles of classification according to accuracy

1.2.1. The classification of measuring instruments according to their accuracy is to be effected by drawing up classes characterizing different levels of accuracy for instruments of the same category.

Note: The Reporting Secretariat C.3 'Accuracy classes of measuring instruments' is the consultative body of the Organization responsible for co-ordinating the OIML Recommendations on the classification of measuring instruments according to their accuracy.

For each accuracy class of one category of instruments, the parameters and characteristics, which determine the particular metrological properties and could cause instrument errors in the measurements carried out with these instruments, must be fixed.

For each category of instruments, a certain number of accuracy classes must be fixed reflecting those levels of metrological properties which correspond to established requirements of science and technology.

Note: The index attributed to a particular accuracy class reflects a certain general level of metrological properties in the instrument but does not directly indicate the accuracy of measurements made with this instrument.

1.2.2. The parameters and characterisics of measuring instruments used when classifying them according to their accuracy are :

– intrinsic error,

– complementary error, caused by variations in the influence quantities, which appears in the variation of the indications of the measuring instruments, in the variation of the quantity reproduced by the material measures or in the variation of the metrological characteristics of the measuring transducers,

– instability with time,

– hysteresis error, and

– other properties affecting the accuracy of the instruments.

Examples :   The parameters and the metrological characteristics are :

– for end gauges: the difference between their real length and their nominal length, the admissible deviation in the flatness and parallelism of their measuring faces, the wringing and instability with time,

– for standard cells: instability with time,

– for electrical indicating measuring instruments: the intrinsic error and the variations in the indications caused by specified changes of the influence quantities (temperature, frequency of alternating current, etc),

– for weighing instruments: the intrinsic error, the hysteresis error, the levelling error.

1.2.3. The parameters and the characteristics defining the metrological properties of measuring instruments and the concrete values of these parameters and characteristics must be fixed in the OIML Recommendations and in the national statutory documents relating to general technical requirements to be satisfied by the instruments of the categories in question, depending on the principle of operation of these instruments, their construction, their intended use and their working conditions.

1.2.4. The parameters and characteristics peculiar to each category of instruments are given in the form of maximum permissible intrinsic and complementary errors (or, instead of these, of variations in the indications caused by variations of the special influence quantities), of maximum permissible instability and of maximum permissible deviations from a reference value for other metrological properties.

1.2.5. With a view to fixing the accuracy classes for measuring instruments, the maximum errors and the norms must be established according to the methods, and be expressed in one of the forms given in Chapter II of this Recommendation. [*]

1.2.6. The series of accuracy classes and their connection with the corresponding maximum errors must comply with the provisions in Chapter III of this Recommendation.

1.2.7. The indices of accuracy classes used in Recommendations and statutory documents and marked on the instruments must correspond to those laid down in Chapter IV of this Recommendation.

1.2.8. The test to determine the conformity of the measuring instruments with their accuracy cases must be carried out by determining each of the parameters and each of the characteristics separately.

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[*] For special cases, standardisation methods other than those given in this Recommendation (see 2.5.1 and the note at the bottom of page 5) can be used.

CHAPTER II

2 Methods of standardizing maximum errors

2.1. Forms of expressing maximum errors

2.1.1. Maximum errors can be expressed in the form :

of absolute errors ― fiducial errors ― relative errors.

The choice of the form for the expression of the error for a particular category of measuring instruments must be made in accordance with their properties, taking into account :

the principle of operation of the instrument, its measuring sequence, its intended use and other factors which could affect the relationship between the errors and the value of the quantity (eg the nature of the error variations along the scale of a measuring instrument).

2.1.2. Maximum errors of measuring instruments are expressed in the form of absolute errors (ie in units of the quantity to be measured or in scale intervals of the instruments),

if these instruments are intended for a field of measurement where it is customary to estimate the level of the accuracy of the results in values expressed in units of the quantity measured or in scale intervals of the instruments used.

Example : It is customary to express the maximum errors of end gauges in units of length (eg in micrometres).

2.1.3. Maximum errors of measuring instruments are expressed in the form of fiducial errors (ie as a percentage of a conventional value, see 2.3.2),

if the absolute errors within the scale limits of the instrument do not depend in practice on the value of the quantity measured and if at the same time it is desirable to express the maximum errors by a number which remains the same for a specified class of instruments where the upper limits of the measurement range are different.

Example : The absolute errors of indicating ammeters do not vary in practice over the various sectors of the scale. At the same time it is convenient to express the maximum errors of ammeters having different upper limits of the measurement range : 1 A, 10 A, 100 A .... by a number which does not vary when changing from one upper limit to another (eg 1 % of the upper limit of the measurement range).

2.1.4. Maximum errors of measuring instruments are expressed in the form of relative errors (ie as a percentage of the value of the quantity measured),

if the absolute errors of the instruments are an approximately linear function of the quantity to be measured and if at the same time it is desirable to express these maximum errors by a number (or numbers) which remain the same for a specified accuracy class of instruments where the upper limits of the measurement range are different.

Example : For a set of resistance coils of 0.01, 0.1, 1, 10, 100, 1000 and 10 000 Ω, it is customary to express the maximum error by the saine number indicating the relative error as a percentage (eg 0.01 % of the nominal value of the resistance of the coils).

2.2. Methods of standardizing absolute maximum errors

2.2.1. If the maximum errors of the group of measuring instruments (in good working order) expressed in the form of absolute errors (2.1.2) do not depend on the value of the quantity to be measured, the maximum errors are fixed according to the formula :

$$\Delta = \pm\, a, \tag{1}$$

Δ – being the absolute maximum error,

a – being a constant value, expressed,

   in the units of the quantity to be measured or in scale intervals.

2.2.2. If the maximum errors of the group of measuring instruments (in good working order) expressed in the form of absolute errors (2.1.2) are in fnear relationship to the value of the quantity measured, the maximum errors are fixed according to the formula :

$$\Delta = \pm\, (a + bx), \tag{2}$$

Δ – being the absolute maximum error,

a – being a constant value expressed in units of the quantity to be measured,

x – being the value of the quantity to be measured,

b – being a positive abstract constant number.

2.2.3. In the case of a more complicated relationship between the value of the maximum errors of the measuring instruments and the value of the quantity to be measured, the maximum errors are fixed in the foret of a function giving approximately this relationship or in the form of a table.

2.3. Methods of standardizing fiducial maximum errors

2.3.1. Fiducial maximum errors (2.1.3) are fixed according to the formula :

$$\gamma = \pm\, \frac{100\, \left|\Delta\right|}{x_N}\, \% = \pm\, p\, \% \tag{3}$$

γ – being the maximum fiducial errof expressed as a percentage of a conventional value x_N,

$\left|\Delta\right|$ – being the absolute maximum error expressed in the same units as the conventional value x_N, disregarding the sign,

p – being a positive abstract number.

2.3.2. The conventional value is equal :

a) for measuring instruments with a linear or exponential scale[(*)], and if the zero mark is at the end of or outside the scale :

   – to the value of the upper limit of the measurement range,

b) for measuring instruments with a linear or exponential scale and if the zero mark lies inside the measurement range.

   – to the greatest value of the limits of the measurement range (disregarding the sign),

however, in the case of electrical measuring instruments, the IEC rule will continue to be applied, which states that the conventional value is equal to the arithmetic sum of the values of the two limits of the measurement range on both sides of the zero, disregarding the sign,

c) for measuring instruments with a non-linear contracted scale [(*)] :

   – to the actual length of the whole scale.

In this case, Δ is expressed in the same units as the scale length,

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[(*)]   For the definition of this term, see Terminology.

d) for measuring instruments where the graduation is in units of a quantity for which a scale with a conventional zero is admissible (eg in ° C) :

  – to the measurement range,

e) for measuring instruments where the nominal value is fixed :

  – to this nominal value,

f) for special cases not covered in the preceding paragraphs, the conventional value will be laid down in OIML Recommendations relating to the corresponding categories of instruments.

2.4. Methods of standardizing maximum relative errors

2.4.1. If the maximum errors of a particular group of measuring instruments (in good working order) expressed in the form of relative errors (2.1.4) do not depend on the value of the quantity to be measured, the maximum errors are fixed in accordance with the formula :

$$\delta = \pm \frac{100 \left| \Delta \right|}{x} \% = \pm c \quad \% \tag{4}$$

δ – being the relative maximum error expressed as a percentage of the value x,

x – being the value of the quantity to be measured,

$\left| \Delta \right|$ – being the absolute maximum error, disregarding the sign, being a positive abstract number.

Note : In the case of measuring instruments and measuring transducers, it is necessary to determine the minimum value X_0 of the quantity to be measured for which formula (4) is valid.

2.4.2. If the maximum errors of a group of measuring instruments (in good working order) expressed in the form of relative errors (2.1.4) depend on the value of the quantity to be measured, the maximum errors are fixed in accordance with the formula [*] :

$$\delta = \pm \frac{100 \left| \Delta \right|}{x} \quad \% \quad = \pm \left[c + d \left(\frac{x_m}{x} - 1 \right) \right] \quad \% \tag{5}$$

δ – being the relative maximum error expressed as a percentage of the value x,

x – being the value of the quantity to be measured,

$\left| \Delta \right|$ – being the absolute error limit, disregarding the sign,

x_m — being the upper limit of the measurement range of the instrument or of the range of variation of the input value of the measuring transducer,

c and d – being positive abstract numbers.

2.5. Other methods of standardizing maximum errors

2.5.1. In exceptional cases, when the methods of expressing the maximum errors and the indices of classes of accuracy referred to above are not applicable, other methods cap be used [**].

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[*]   Formula (5) is equivalent to the formula :

$$\delta = \pm \left(c' + d \, \frac{x_m}{x} \right) \tag{5'}$$

where c' = c – d, but it is more convenient because 'c' represents the limit of the relative error expressed as a percentage in the case of $x = x_m$. The co-efficient 'd' is the same in both formulae and evaluates the increase in the relative maximum error expressed as a percentage in the case of $x < x_m$.

[**]   See 1.2.5 and the note at the bottom of page 5.

CHAPTER III

ACCURACY CLASSES AND CORRESPONDING MAXIMUM ERRORS

3.1. Series of accuracy classes

3.1.1. For measuring instruments where the maximum errors are expressed in accordance with 2.2 (absolute errors), the specified series of accuracy classes are designated by capital letters or Roman numerals.

3.1.2. For measuring instruments where the maximum errors are expressed in accordance with 2.3.1 and 2.4.1 (fiducial and relative errors), the series of accuracy classes are determined, corresponding to the numbers :

$1 \times 10_n$, $1.5 \times 10_n$ $1.6 \times 10_n$, $2 \times 10_n$, $2.5 \times 10_n$, $3 \times 10_n$, $4 \times 10_n$, $5 \times 10_n$, $6 \times 10_n$
where $n = 1, 0, -1, -2$, etc

For the same value of 'n', the number of classes is restricted to 5.

Notes :   1   It is prohibited to use simultaneously classes 1.5×10^n and 1.6×10^n.
            2   The number 3×10^n is reserved for exceptional use in technically justified cases.

3.1.3. For measuring instruments where the errors are expressed in accordance with the requirements of 2.4.2 (relative error depending on the value of the quantity measured), series of accuracy classes are determined and identified by the two numbers c and d referred to in formula (5).

These numbers c and d, for each accuracy class, must be taken from the series prescribed in 3.1.2, the ratios between these two numbers being laid down in the Recommendations concerning the various categories of instruments, subject to c being greater than d.

3.1.4. For measuring instruments where the accuracy classes are characterised not by the errors, but by other metrological properties, the series of accuracy classes must be fixed in accordante with the requirements of 3.1.1 or 3.1.2 according to the method adopted to express these properties.

3.2. Parameters and characteristics of measuring instruments as a function of the accuracy classes.

3.2.1. The OIML Recommendations and the national regulations concerning the special categories of measuring instruments, which provide for their distribution according to their accuracy, must fix the series of appropriate accuracy classes and maximum errors, as well as the conditions under which they are determined, in particular:

a) the maximum intrinsic error (or errors) and the corresponding reference conditions,

b) the maximum complementary errors and the nominal ranges of use for each influence quantity, or for measuring equipment,
   the permissible limits of variations in indications of specified changes in the influence quantities,
   the limits of the admissible instability on the time scale,

d) the parameters and characteristics determining all the other metrological properties of the instruments.

Note: The reference values and permissible deviations of the influence quantities must be fixed.

3.2.2.The maximum intrinsic errors for each category of measuring instruments must be expressed in one of the forms given in 2.1.

To classify instruments according to their accuracy, it is preferable to use the relative or fiducial error because the class index gives a direct indication of the level of accuracy of an instrument used under reference conditions.

3.2.3. The intrinsic error for measuring instruments in a stated accuracy class must not exceed:

a) for instruments where the accuracy classes are designated by capital letters or by Roman numerals (3.1.1):

– the values fixed by the regulations relating to each category of these instruments (in a series of accuracy classes the letters nearest the beginning of the alphabet or the smallest figures must correspond to the smallest maximum errors),

b) for instruments where the accuracy classes are designated by numbers of the series indicated in 3.1.2:

– the value corresponding to the number forming part of the index of the accuracy class;

c) for instruments where the accuracy classes are designated by two numbers c and d (3.1.3):

– the value calculated from formula (5) (2.4.2) substituting in this formula the c and d values corresponding to the accuracy class.

3.2.4. The maximum errors evaluated according to formulae (2) and (5) or by functional relationships must be rounded after calculation and expressed by not more than two significant figures.

3.2.5. The maximum complementary errors, or for measuring instruments the limits of the variations in indications caused by changes in the particular influence quantities, are usually expressed in the same form as the intrinsic error.

3.2.6. The maximum complementary errors or, for measuring equipment, the limits of the indicated variations due to variations in the particular influence quantity must be fixed by:

a) the indication of a specific value for the maximum error or for the variation in the indications of the instrument for the nominal range of use for the corresponding influence quantity, or

b) the indication of the functional relationship between the error or the variation in indications and the specified variation in the influence quantity. If the error is a linear function of the influence quantity it is possible to fix the ratio between the change in the maximum error and the specified change in the influence quantity (ie the influence factor of this quantity).

3.2.7. The permissible instability limits on a time scale inherent in measuring instruments are usually specified in the same form as the intrinsic error.

The specific limits of permissible instability and the corresponding appropriate time interval must be stated in the Recommendations defining the series of accuracy classes for particular categories of measuring instruments.

3.2.8. For measuring instruments intended to be used in different conditions it is possible to authorise, within the framework of the same accuracy class, different maximum complementary errors or different variations of the maximum indications (4.2.3).

3.2.9. The requirements for the other metrological properties of measuring instruments which are not prescribed by 3.2.3 - 3.2.7 must be fixed by the Recommendations relating to the categories pertaining to these instruments.

3.2.10. The requirements concerning maximum errors and the norms given in this Recommendation must be applied both to new or repaired measuring instruments, and to those already in service.

For certain new instruments it is possible to fix more rigorous requirements for the metrological properties known in advance to be liable to vary during subsequent use of the instruments.

Example: Since during use the mass of weights decreases continuously as a result of wear, the norms for some types of weights can specify adjustment such that the mass of new weights is not less than the nominal value.

3.3. Accuracy classes for combined instruments

3.3.1. Two or more accuracy classes may be fixed for measuring instruments comprising two or more ranges of measurement.

3.3.2. For universal or combined measuring instruments (intended to measure two or more different physical quantities), several accuracy classes can be fixed in regard to the different quantities to be measured.

Example: For combined electrical measuring equipment intended to measure in d.c. and a.c. two accuracy classes can be fixed, one characterising the properties of the equipment on d.c. the other those of the equipment on a.c.

CHAPTER IV

4. Indication and marking

4.1. Indications used in the documentation

4.1.1. Accuracy classes of measuring instruments where the maximum errors and norms are expressed in the form of absolute errors, in accordance with 2.2.1 and 2.2.2, are designated by capital Roman letters which may bear an index or by Roman numerals.

   Example :   Gauge block of accuracy class - A.

4.1.2. Accuracy classes of measuring instruments where the maximum errors and the. norms are expressed in the form of a relative error, in accordance with 2.4.1, or in the form of a fiducial error, in accordance with 2.3.1, are designated by numbers related to the value of the maximum intrinsic error expressed as a percentage.

   Example: Ammeter of accuracy class - 0.5.

4.1.3. Accuracy classes of measuring instruments where the maximum errors are expressed as a relative error, in accordance with 2.4.2, are designated by two numbers representing respectively the terms c and d of formula (5), separated by an oblique stroke.

4.1.4. In documents relating to the manufacture and use of measuring instruments (recommendations, regulations, norms, specifications, drawings, descriptions, etc), it is recommended that the indices of the accuracy class be accompanied by an indication of the regulations fixing the class in question.

4.1.5. It is permissible to use in these documents the accuracy class indices given in 4.2.1.

4.2.   Markings to be shown on the measuring instruments.

4.2.1. The dials, data plates or housings of the measuring instruments must bear the accuracy class indices consisting of the numbers, capital Roman letters or Roman numerals specified in 4.1, accompanied by the appropriate signs shown in Table 1 below.

TABLE 1

Indices of accuracy classes to be marked on measuring instruments

Method of expressing the errors	Paragraph	Accuracy class or maximum error (examples)	Index of accuracy class (for the given example)
Absolute error	2.2	Class M	M
Fiducial error, the conventional value being expressed by the length of scale	2.3.2 a , b, d, e	$\gamma = \pm\, 1.5\ \%$	1.5
Fiducial error, the conventional value being expressed by the length of scale	2.3.2.c	$\gamma = \pm\, 0.5\ \%$	0.5 ⟱
Constant relative error	2.4.1	$\delta = \pm\, 0.5\ \%$	⬭ 0.5
Relative error increasing with decrease in the quantity to be measured	2.4.2	$\delta = \pm\left[\, 0.02 + 0.01\left(\dfrac{x_m}{x} - 1\right)\right]\%$	0.02/0.01

Notes: 1 The examples of indices, given as illustrations in Table 1, have been chosen arbitrarily.

2 It is not essential to indicate the accuracy class on the material measures for which distinguishing external features, inherent to this class, are specified in the corresponding OIML Recommendations.

Example: It is possible to omit the indication of the index of the accuracy class on weights which, in accordance with the OIML Recommendation, have a special shape for the accuracy class in question.

3 The statement of the accuracy class on measuring instruments with a contracting non-linear scale can be completed, by way of information, by the value of the relative error expressed as a percentage of the value of the quantity to be measured for a part of the scale designated by special signs (eg dots or triangles). This value must be followed by a sign and encircled ⬭ 10 % it being understood that this sign does not represent a class index.

13

4.2.2. A reference to the statutory national regulation, giving the general technical requirements for a given category of measuring instruments, must also be marked on the data plates or housings of the instruments, by the side of the class index.

Instead of the designation of the national regulation, it is permissible to give the sign of conformity to national norms.

In cases where for one accuracy class different limits of errors (or of variations of the indications) are fixed, according to the working conditions of the instruments, the conventional indications specified in statutory documents, for these working conditions, must also be marked on the instrument.

4.2.3. When in accordance with statutory requirements, an indication of the reference value or of the reference range of an influence quantity must be marked on the instrument, this indication must be underlined.

Examples of the above-mentioned indications to be marked on the measuring instrument as well as the indications of the nominal working range of an influence quantity are given in Table 2 where the frequency of an a.c. current is shown as an example of an influence quantity.

TABLE 2

Reference value or range of the frequency in Hz	Nominal working range in Hz	Designations
400	_	**400** Hz
45 . . . 55	_	**45 . . . 55** Hz
50	20 . . . 120	20 . . . **50** . . . 120 Hz
40 . . . 60	40 . . . 120	40 . . . **40 . . . 60** . . . 120 Hz
40 . . . 60	10 . . . 120	10 . . . **40 . . . 60** . . . 120 Hz

GRAPHIC REPRESENTATION

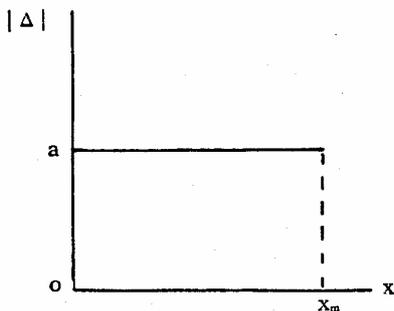## of maximum errors

standardized in accordance with formulae (1) to (5)
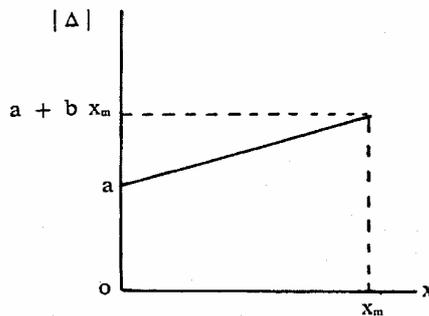
- original French text
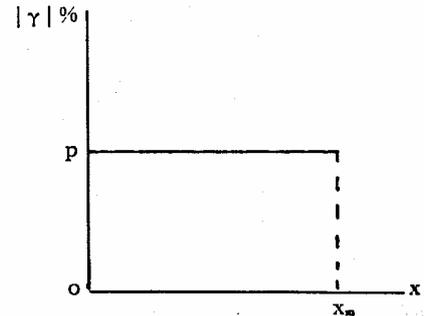
point 2.2.1. formule 1
$$\Delta = \pm a$$

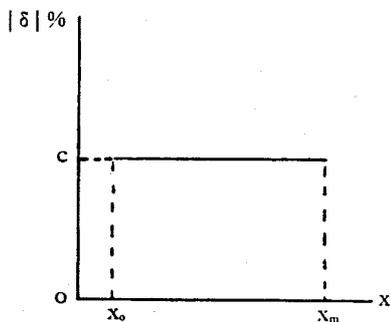### point 2.2.2. formule 2
$$\Delta = \pm (a + bx)$$

point 2.3.1. formule 3
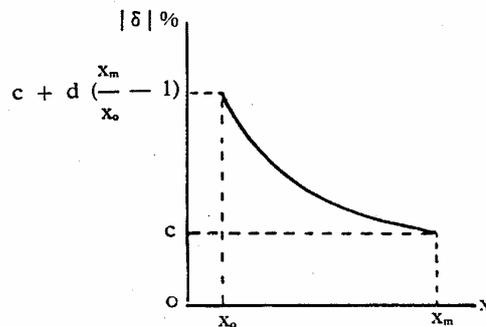$$\gamma = \pm \frac{100\ |\Delta|}{x_N}\ \% = \pm p\%$$

point 2.4.1. formule 4
$$\delta = \pm \frac{100\ |\Delta|}{x}\ \% = \pm c\%$$

point 2.4.2. formule 5
$$\delta = \pm \frac{100\ |\Delta|}{x}\ \% = \pm \left[c + d\left(\frac{x_m}{x} - 1\right)\right]\%$$

Symbols used

$|\Delta|\,|\gamma|\,|\delta|$	=	absolute, fiducial and relative maximum errors respectively, disregarding the sign,
a	=	constant value expressed in units of the quantity to be measured or in scale intervals,
b, p, c, d	=	positive abstract numbers,
x_m	=	upper limit of the measuring range of the instrument or of the range of variation of the input value of the measuring transducer,
x_o	=	minimum value of the quantity to be measured, above which formulae 4 and 5 are applicable,
x_n	=	conventional value.

TERMINOLOGY

DEFINITIONS AND SHORTENED FORMS OF CERTAIN
TERMS USED IN THE RECOMMENDATION

A   Definitions

1   Fiducial error

Quotient of the absolute error and a conventional value characterizing the measuring instrument. This conventional value can be, for example :

– the upper limit of the scale range or the upper limit of the measurement range,

– the value of the scale range or the value of the measurement range,

– the scale length,

– the number of scale divisions.

2   Non-linear contracted scale

Scale where the length of the scale divisions decreases progressively and where the scale mark corresponding to the halfsum $C = \frac{1}{2} (A + B)$ of the limits A and B of the scale range lies between 65 % and 100 % of the length of the scale corresponding to the measurement range.

Examples : logarithmic scale, hyperbolic scale.

3   Exponential scale

Scale where the length of the scale divisions increases or decreases progressively but which, in the latter case, does not have the characteristics of the scale defined in 2 above.

B   Shortened forms used

1   Maximum error

Instead of the expression 'maximum permissible error'.

2   Norms

Instead of the expression 'norms relating to metrological properties other than errors'.

Contents