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Principles of selection of characteristics for the examination of measuring instruments

Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels

OIML D 15 Edition 1986 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

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

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

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

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

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

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PRINCIPLES of SELECTION of CHARACTERISTICS for the EXAMINATION of ORDINARY MEASURING INSTRUMENTS

1. General

This International Document defines the principles for the selection of characteristics to be evaluated during examination of ordinary measuring instruments, hereafter referred to as measuring instruments. This Document may, in many cases, also be applied to the selection of characteristics for use in the examination of measurement standards.

The term examination is used to describe operations carried out in connection with :

— the statutory evaluation of measuring instruments (see OIML International Document No 3 « Legal qualification of measuring instruments »),

— the evaluation of measuring instruments by manufacturers, repairers and users of measuring instruments.

This Document applies to those characteristics of measuring instruments which describe the metrological qualities of these measuring instruments [*].

The selection of characteristics is based on those metrological characteristics which are defined in the OIML International Documents No ... «Measuring instruments. General metrological characteristics subject to standardization», and No... «Measuring instruments. Metrological characteristics of dynamic properties subject to standardization» [**] and on other characteristics used to describe the metrological qualities of measuring instruments.

In this Document, account is not taken of other characteristics required for the evaluation of measuring instruments, such as:

— characteristics used to specify constructional properties and/or requirements for installation,

— characteristics used to specify requirements relating to health protection, operator safety and fire prevention,

— reliability parameters and criteria indicative of the ability of a measuring instrument to prevent a measurement outside the maximum permissible errors in cases of component or sub-assembly failure,

— characteristics and criteria used to specify the condition of a measuring instrument, such as the realization of the scale, inscriptions and identifications.

The Appendix to this Document contains guidelines for the attribution of characteristics to the types of examinations and distinction is made only between pattern evaluation and examination of a measuring instrument.

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[*] The basic characteristics of measuring instruments are given in Chapter 9 of the « Vocabulary of legal metrology », 1978, and in Chapter 5 of the « International vocabulary of basic and general terms in metrology », 1984.

[**] International Documents developed by the Reporting Secretariats SP 21-Sr 1 and 2.

The OIML Secretariats should take account of the principles indicated in this Document when preparing specific texts defining the characteristics to be used for the examination of measuring instruments. These principles may also be taken into consideration by other national and international organizations responsible for the preparation of specifications.

2. Terminology

2.1. Measuring instrument

A device intended to make a measurement, alone or in conjunction with other equipment (VIM 4.01).

Note: In this Document, the term measuring instrument is used as a common denomination covering: material measures, measuring instruments, measuring transducers and measuring systems.

2.2. Ordinary measuring instrument

A measuring instrument intended for ordinary use but not for the verification of other instruments (VML 6.1.3).

2.3. Pattern evaluation

The examination of one or more measuring instruments of the same pattern which are submitted by a manufacturer to the National Service of Legal Metrology; this examination includes the tests necessary for the approval of the pattern (VML 2.2).

Notes : Pattern evaluation is not limited to the National Service of Legal Metrology or the metrological services of other government agencies, but may also be undertaken by any other officially authorized test centre as well as by manufacturers and users of measuring instruments.

The purpose of pattern evaluation is not necessarily pattern approval, its purpose may also be, for example, assessment of suitability for use.

2.4. Examination of a measuring instrument

All the operations carried out with a view to establishing that the measuring instrument conforms either to the requirements of the regulations for verification or to the recommendations of a standard or to technical specifications (VML 2.3).

2.5. Initial verification

The verification of a new measuring instrument which has not been verified previously (VML 2.4.2).

2.6. Subsequent verification

Any verification of a measuring instrument which follows the initial verification:
mandatory periodic verification,
verification after repair,
or verification made before the expiry of the period of validity of the periodical verification made either :
at the request of the user,
or because for some reason the stamp is no longer valid for the remainder of this period of validity (VML 2.4.3).

2.7. Complete verification

A subsequent verification of a measuring instrument for which the full examination of the instrument, as for initial verification, is required (VML 2.4.4).

2.8. Simplified verification

A subsequent verification of a measuring instrument for which a simplified examination is allowed (VML 2.4.5).

2.9. Metrological supervision

Procedures for control exercised in respect of the manufacture, installation and repair of measuring instruments, or in respect of their use, to check that they are used correctly and honestly.

It extends also to control of correctness of the quantities indicated on prepacked articles (VML 2.6).

3. Principles for selection of characteristics

3.1. General principles

3.1.1. The examinations should be carried out in the same manner (with reference to the selected characteristics, and taking into account the purpose of the examination and the category or pattern of the measuring instruments) when performed by the National Service of Legal Metrology, by metrological services of other government agencies, by any other officially authorized test centres, or by manufacturers and users of measuring instruments.

3.1.2. The characteristics should be selected so that it is actually possible to determine or check the value of each specified characteristic.

3.1.3. The characteristics which denote the error behaviour of measuring instruments sould, as far as possible, be selected to allow evaluation of instrumental error for conditions under which the measuring instrument is used. As far as possible, the conditions under which these characteristics are checked should be selected so that they correspond to these conditions of use.

3.1.4. The measurement tasks to be carried out with the measuring instruments determine the selection of characteristics and the uncertainty of measurement with which the values of these characteristics are determined. In the case of multipurpose measuring instruments which can be used to carry out a large variety of measurement tasks, manufacturer's specifications or any regulations covering this category of measuring instruments should be taken into account. Among those characteristics which denote a quality of a measuring instrument, preference should be given to the characteristic which is least costly to check. This characteristic should also comply with the requirements in point 3. The choice of a characteristic which is costly to check is nevertheless justified if the measurement tasks require this or if the anticipated economic benefits are substantially greater than those obtained when a characteristic less costly to check is selected.

3.2. Pattern, evaluation

3.2.1. Appropriate characteristics should be selected which make possible a comprehensive metrological assessment of the pattern. Keeping in mind the required uncertainty, one should be especially careful to include all of the essential characteristics of the measuring instruments of a given pattern which are necessary for the evaluation of the quality of the measuring instruments and which affect the measurement results.

3.2.2. The pattern evaluation program should include the characteristics specified for examination of a measuring instrument.

3.2.3. It should be determined whether the group of characteristics listed in the technical documentation covering the measuring instrument includes those characteristics which have to be selected in accordance with the International Documents developed by the Reporting Secretariats SP 21-Sr *1* and 2, or in any other normative texts for the measuring instrument referred to in these DI's. The characteristics indicated in the technical documentation covering the measuring instrument should be checked and evaluated, provided they meet the conditions in points 3.1, 3.2.1 and 3.2.2. If they do not, other characteristics should be selected for the examination, which however, should also meet the conditions in points 3.1, 3.2.1 and 3.2.2.

3.2.4. The characteristics for examination of a measuring instrument may be specified as a result of pattern evaluation, taking account of the time interval between examinations (see DI No 3, points 4.1, 6.1 and 6.2).

3.3. Examination of a measuring instrument

3.3.1. For initial and complete verifications, as well as for examinations equivalent to initial or complete verifications, those characteristics should be selected that may vary as a result of the construction and technique used in the manufacture of the measuring instrument, and that are critical to its use.

3.3.2. For simplified verifications as well as for examinations equivalent to simplified verifications, those characteristics should be selected that are likely to change during use and storage of the measuring instruments.

3.3.3. When construction, technology and quality of materials give assurance that the value of a characteristic varies little or not at all within one, several or all production runs, this characteristic needs to be subjected to a sampling inspection only. Sampling inspections are also to be made on measuring instruments having a one-time use (see DI No 3, point 5.5.2).

3.3.4. For the metrological supervision of measuring instruments in service, characteristics should be selected which are in keeping with the requirements of the actual measurement procedure.

4. Indications concerning preparation of specific normative texts

Specific normative texts prepared on the basis of this Document should be so worded that they are easy to use. Characteristics and test specifications should be given in such a way that direct application to practical metrology is possible.

APPENDIX 1

ATTRIBUTION OF THE CHARACTERISTICS TO PATTERN EVALUATION AND TO EXAMINATION OF A MEASURING INSTRUMENT

The following Table is a guideline for the attribution of characteristics to the two basic types of examination, pattern evaluation and examination of a measuring instrument. In view of the large variety of measuring instruments, further subdivision of the examination of a measuring instrument into:

— verification, including the different types of verification,
— calibration,
— metrological supervision,

is not appropriate in this Document. It should be done when selecting the characteristics for specific categories or patterns of measuring instruments. Deviations from and additions to this guideline are admissible, provided proper account is taken of the principles in point 3 of this Document.

In the Table, the column « Examination of a measuring instrument » assumes prior pattern evaluation, and should be supplemented with characteristics from the column «Pattern evaluation» when examination of a measuring instrument is not preceded by pattern evaluation. The Table also contains examples of application of the guidelines for two categories of measuring instruments. These examples are given only for guidance and one may deviate in the case of a specific measuring instrument, depending on the type of examination.

The terms used in the Table are in line with VML 1978, VIM 1984, IEC Publication 50 (351) 1975, IEC Vocabulary 1983, and the International Documents developed by the Reporting Secretariats SP 21-Sr 1 and 2.

Comments on the examples given in the Table are presented in Appendix 2.

Note: the definitions of the terms from the IEC Publications have not been adopted verbatim since the IEC Publications refer to control systems.

TABLE

Characteristic	Guidelines for attribution of characteristics		Examples of attribution of characteristics (*)			
			Electro-mechanical platform scale		Insulated NiCr-Ni thermocouple	
	Pattern evaluation	Examination of a measuring instrument	Pattern evaluation	Examination of a measuring instrument	Pattern evaluation	Examination of a measuring instrument
1	2	3	4	5	6	7
Total nominal value of a material measure	X	X				
Scale range	X	X	X			
Scale spacing	X	X				
Scale interval	X	X	X	X		
Specified measuring range	X	X	X		X	X
Maximum/minimum capacity	X	X	X	X	X	
Characteristic curve of a measuring instrument	X		X	X	X	X
Maximum permissible overload	X	X	X		X	X
Maximum/minimum frequency of measurement	X					
Matching characteristics of a measuring instrument	X		X		X	
Error curve of a measuring instrument	X		X	X	X	
Maximum permissible values of the error of a measuring instrument	X	X	X	X	X	X
Expectation (mean) and standard deviation of the error of the measuring instruments of a pattern	X					
Maximum permissible values of the systematic component of the error of a measuring instrument	X	X				
Expectation (mean) and standard deviation of the systematic component of the error of the measuring instruments of a pattern	X					
Maximum permissible values of the random component of the error of a measuring instrument	X	X	X	X		

(*) The examples are described in Appendix 2.

Characteristic	Guidelines for attribution of characteristics		Examples of attribution of characteristics (*)			
			Electro-mechanical platform scale		Insulated NiCr-Ni thermocouple	
	Pattern evaluation	Examination of a measuring instrument	Pattern evaluation	Examination of a measuring instrument	Pattern evaluation	Examination of a measuring instrument
1	2	3	4	5	6	7
Hysteresis error	X	X	X	X		
Sensitivity	X	X	X		X	
Discrimination threshold	X	X	X	X		
Passivity of a meter	X	X				
Step response of a measuring instrument	X					
Unit impulse response of a measuring instrument	X					
Transfer function of a measuring instrument	X				X	
Frequency response of a measuring instrument	X					
Gain of a measuring instrument	X					
Phase angle of a measuring instrument	X					
Response time of a measuring instrument	X	X			X	
Dead time of a measuring instrument	X	X				
Time constant of a measuring instrument	X	X				
Damping ratio of a measuring instrument	X	X				
Limit frequency of a measuring instrument	X	X			X	
Nominal range of use (for a given influence quantity)	X		X		X	X
Influence function	X		X			
Variation of the value of a characteristic due to variation of an influence quantity	X	X	X	X		

Definitions of terms used in the Table

— Total nominal value of a material measure

The total value of the quantity reproduced by a material measure and which is indicated on that measure (VML 5.3.3).

— Scale range

For a given scale, the range of scale values between the extreme scale marks.

Note: The scale range is expressed in the units marked on the scale, regardless of the units of the measurand, and is normally stated in terms of its lower and upper limits, for example 100 °C to 200 °C (VIM 4.21).

— Scale spacing

The distance between any two successive scale marks measured along the same line as the scale length.

Note: Scale spacing is expressed in units of length, regardless of the units of the measurand or the units marked on the scale (VIM 4.23).

— Scale interval

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

Note: Scale interval is expressed in the units marked on the scale, regardless of the units of the measurand (VIM 4.24).

— Specified measuring range
— Specified working range

The set of values of a measurand for which the error of a measuring instrument is intended to lie within specified limits.

Note: The upper and lower limits of the specified measuring range are sometimes called the maximum capacity and minimum capacity respectively (VIM 5.04).

— Characteristics curve of a measuring instrument

Graph which shows the values, in steady-state, of the output signal of a measuring instrument as a function of the input signal (IEC 50 (351) 04.01 and IEC 82/P 2.2.2.01).

— Overload of a measuring instrument

a) For measuring instruments other than meters: the value of that part of the quantity measured which exceeds the maximum capacity of the instrument.

b) For meters: the value of that part of the load which exceeds the maximum load of the meter.

Notes: 1) The expression « maximum permissible overload » is used to denote the limiting value permitted for the overload.

2) A distinction is made between « short term » and « long term » overloads (VML 9.2.7).

— Maximum (minimum) frequency of measurement

The number of measurements in unit time above (below) which the results of measurement obtained from the instrument are liable to be affected by an error greater than the maximum permissible error (VML 9.2.8).

Matching characteristic of a measuring instrument

Characteristic that reflects the potential of the instrument for interaction with any component connected to its input or output (for example, with the objects of measurement or with other measuring instruments), where this interaction affects the instrumental component of the error (SP21-Sr 1/4.4).

— Error (of indication) of a measuring instrument

The indication of a measuring instrument minus the (conventional) true value of the measurand.

Note: For a material measure, the indication is its nominal or marked value (VIM 5.24).

— Limits of error (of a measuring instrument)

— Maximum permissible errors (of a measuring instrument).

The extreme values of an error permitted by specifications, regulations, etc. for a given measuring instrument (VIM 5.23).

Note: The maximum permissible values may be fixed for the error or components of error of a measuring instrument, depending on the purpose of the examination. These values may be one-sided (all positive or all negative) or two-sided (negative and positive).

— Error curve of a measuring instrument

A curve which represents the error of a measuring instrument as a function, either of the quantity measured or of any other quantity which has an influence on this error.

Note: The error curve represents the determined component of the error (VML 8.6).

— Systematic component of the error of a measuring instrument

The component of the error of a measuring instrument that remains constant for the same value of a measured or reproduced quantity and under the same conditions of use of a measuring instrument or which varies according to some law when these conditions are changed (SP21-Sr1/2.11 - see also « systematic error », VML 8.4 and « bias error », VML 5.28).

Notes: 1) The systematic component of an error of a measuring instrument does not include errors caused by hysteresis.

2) A systematic error can be partially eliminated by an appropriate correction. After correction, a certain proportion of the systematic error remains and, in practice, can only be estimated by way of the limits of the interval wherein it may lie.

— Random component of the error of a measuring instrument

The component of the error of a measuring instrument that varies stochastically for the same value of a measured or reproduced quantity and under the same conditions of use of a measuring instrument. This is a centered random quantity or a centered random process (SP21-Sr1/2.13 - see also « random error », VML 8.1.2 and « repeatability error », VIM 5.30).

Note: The random component of the error of a measuring instrument may be described by the standard deviation, confidence limit, range of dispersion or other characteristics. From these characteristics a suitable characteristic has to be selected for the examination of the measuring instrument taking into account the principles stated in point 3 of this Document.

— Expectation (mean value) and standard deviation of the error of the measuring instruments of a pattern

Characteristics of the frequency distribution of the error of the measuring instruments of a pattern.

Note: The frequency distribution or its characteristics are determined by the errors which are found during the examination by sampling of the measuring instruments of a pattern (SP21-Sr1/6.5 and 6.6).

— Expectation (mean value) and standard deviation of the systematic component of the error of the measuring instruments of a pattern

Characteristics of the frequency distribution of the systematic component of the error of the measuring instruments of a pattern.

Note: The frequency distribution or its characteristics are determined by the systematic components of the error which are found during the examination by sampling of the measuring instruments of a pattern (SP 21-Sr 1/6.5 and 6.6).

— Hysteresis error

The difference between the indications of a measuring instrument when the same value of the quantity measured is reached by increasing or decreasing that quantity.

Note: In certain cases, the hysteresis error is determined by the difference between the values of the quantity measured which correspond to the same indication when reached respectively by increasing and by decreasing the quantity (VML 9.7.1, see also hysteresis - VIM 5.15).

— Sensitivity

The change in the response of a measuring instrument divided by the corresponding change in the stimulus.

Note: Sensitivity may depend on the value of the stimulus (VIM 5.10).

— Discrimination threshold

The smallest change in a stimulus which produces a perceptible change in the response of a measuring instrument.

Note: The discrimination threshold may depend on, for example, noise (internal or external), friction, damping, inertia, quantization (VIM 5.12).

— Passivity of a meter

The smallest load which causes movement of the indicating device of a meter.

Note: « Passivity » is analogous to discrimination threshold but is related to the meter load and not to the quantity measured (VML 9.8.4).

— Step response of a measuring instrument

The time response of a measuring instrument to a step in the input signal.

Note: The time response to a unit step is called the unit step response (SP 21-Sr 2/2.11).

— Unit impulse response of a measuring instrument

The time response of a measuring instrument produced by a delta function input signal (SP21-Sr2/2.12).

— Transfer function of a measuring instrument

In a linear measuring instrument, the ratio of the Laplace transform of the output signal to the Laplace transform of the corresponding input signal, with all initial conditions zero (SP21-Sr2/2.13).

— Frequency response of a measuring instrument

In a linear measuring instrument, the ratio of the Fourier transform of the output signal to the Fourier transform of the corresponding input signal, with all initial conditions zero.

Note: The frequency response coincides with the transfer function taken on the imaginary axis of the complex plane (SP21-Sr 2/2.14).

— Gain of a measuring instrument

For a linear measuring instrument in sinusoidal steady-state, the ratio of the amplitude of the output signal to the amplitude of the corresponding input signal.

Note: the gain is the absolute value of the frequency response (IEC 50 (351) 04.14 and IEC 82/P 1.2.0.12).

— Phase angle of a measuring instrument

For a linear measuring instrument in sinusoidal steady-state, the phase difference between the output signal and the corresponding input signal.

Note: The phase angle of a measuring instrument is the argument of the frequency response (SP21-Sr 2/2.16).

— Response time of a measuring instrument

The time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits of its final steady value (VIM 5.19).

— Dead time of a measuring instrument

Time interval between the instant when a variation of the input signal is produced and the instant when the consequent variation of the output signal starts (IEC 50(351) 04.21 and IEC 82/P 1.2.0.17).

— Time constant of a measuring instrument

The time constant T is the time required to complete 63,2 % of the total rise or decay of the output of a first order linear measuring instrument, initiated by a step or an impulse to the input.

Notes : 1) Such a time response is described by $A\ (1 — e^{-t/T})$ or $Ae^{-t/T}$ where T is the time constant.

2) In higher order systems, there is a time constant for each of the first order components of the process. In a Bode diagram, corner frequencies appear at $\omega = 1/T$ (IEC 82/P 1.2.0.18).

— Damping ratio of a measuring instrument

For a linear measuring instrument described by the second order differential equation

$y'' + 2\gamma\omega_0 y' + \omega_0^2 y = 0$, the factor γ in the equation is the damping ratio.

Notes : 1) ω_0 is called the angular resonance frequency of the measuring instrument.

2) The damping ratio characterizes the dying out of an oscillation and is calculated by the decrement of two successive semi-oscillations of the output signal (SP21-Sr2/2.17).

— Limit frequency of a measuring instrument

Frequency at which the decrement of the output signal to the input signal does not fall short of or exceeds a fixed bound.

— Nominal range of use (for a given influence quantity)

The range of values of an influence quantity within which the corresponding complementary errors do not exceed the maximum permissible values (VML 9.1.4).

— Influence function

The functional dependence of variations in a metrological characteristic of a measuring instrument upon variation in an influence quantity or in a set of influence quantities (SP21-Sr 1/2.16).

— Variation of the value of a characteristic due to variation in an influence quantity

The difference between the value of a characteristic corresponding to a given value of an influence quantity within normal conditions of use and the value of this characteristic corresponding to the reference value of the influence quantity.

Notes: 1) This difference carries either a positive or a negative sign.

2) It is not necessary to determine during the examination of a measuring instrument in the entire nominal range of use whether or not the maximum permissible variation of the values of characteristics due to variation of an influence quantity is exceeded (SP 21-Sr 1/2.18).

— Normal conditions of use

The conditions which must be fulfilled in order to use a measuring instrument correctly, taking account of its design, construction and purpose.

Notes: 1) The normal conditions of use can refer, among other things, to the type and condition of the subject of the measurement, the value of the quantity measured, the values of the influence quantities, the conditions under which the indications are observed, etc.

2) When these conditions are indicated on the instrument or in its method of use, they are termed « nominal conditions » (VML 9.1 - see also « rated operating conditions », VIM 5.05).

APPENDIX 2

COMMENTS ON EXAMPLES GIVEN IN THE TABLE (*)

1. Electro-mechanical platform scale (4 load cells, electronic weighing equipment, printer) of accuracy class (III)

scale range	0 kg to 200.4 kg
verification scale interval	e = 0.1 kg
specified measuring range	5 kg to 200 kg
maximum capacity	2 000 e = 200 kg
minimum capacity	50 e = 5 kg
nominal characteristic curve	given by the scale, recorded characteristic curve : indication = f (load)
maximum permissible load	120 % of maximum capacity = 240 kg (electronically set)
matching characteristics	— load cell : internal resistance : 350 Ω ± 2 Ω voltage supply : 10 V — electronic weighing equipment : output signal level and code : BCD code with a parity bit, TTL logic
error curve	determination of error as a function of the load (during pattern evaluation)
maximum permissible errors	pattern evaluation, initial verification : ± 0.5 e for 0 kg ≤ load ≤ 50 kg ± 1.0 e for 50 kg < load ≤ 200 kg (without allowance for the rounding error resulting from digital indication)
repeatability	the difference between measured values obtained during 2 or 3 weighings of the same load and under the same conditions may not exceed the maximum permissible absolute value of the error for the load
hysteresis error	characteristic curve recorded for increasing and decreasing loads : maximum permissible error must not be exceeded
sensitivity	examination of load cell : $\frac{\text{variation of the output signal}}{\text{variation of load}} = \frac{200 \text{ mV}}{200 \text{ kg}}$

(*) The characteristic values partially depend on the pattern of the measuring instrument, and cannot be generalized.

discrimination threshold	load variation of 1.4 e : variation in indication of at least 1 e = 0.1 kg
nominal range of use	— temperature : from — 10 °C to + 40 °C — line voltage : 220 V $^{+\ 10\ \%}_{-\ 15\ \%}$ — line frequency : 50 Hz ± 2 %
influence function	— determination of characteristic curve as a function of temperature ; check that maximum permissible errors are not exceeded
maximum permissible variation of values of the characteristics in the nominal range of use due to variation of an influence quantity	— at zero indication temperature change of 5 K : maximum permissible variation of indication 1 e = 0.1 kg (RI 3, point 14.2.2) — time dependent load : a) after loading for 0.5 hours : maximum permissible variation of indication on returning to zero 0.5 e = 0.05 kg (RI 3, point 9.3.2) b) during loading for 4 hours : maximum permissible variation of indication corresponds to maximum permissible error (RI 3, point 9.3.1) — eccentric loading : check that maximum permissible errors are not exceeded (RI 3, point 11.3)

Note : see also International Recommendation No 3

2. Insulated NiCr-Ni thermocouple (junction enclosed in insulator, without indicating or recording instruments)

measuring range: from 0 °C to 1 000 °C

maximum capacity: 1 000 °C

minimum capacity: 0 °C

characteristic curve

temperature °C	thermoelectric voltage mV
0	0.000
100	4.095
200	8.137
300	12.207
—	—
—	—
—	—
900	37.325
1 000	41.269

maximum permissible overload: 1 200 °C

matching characteristic: internal resistance 20 Ω

maximum permissible error: ± 0.12 mV for temperatures from 0 °C to 400 °C with linear increase up to ± 0.31 mV at 1 000 °C

sensitivity: 0.041 mV/K (mean)

transfer function:

$$G(p) = \frac{1}{(1 + pT_1)(1 + pT_2)}$$

where :
p = Laplace operator
T_1 = 14 s
T_2 = 1 s
measured in air, v = 3 m/s

response time: 43 s
measured in air, v = 3 m/s

limit frequency: 0.012 Hz
measured in air, v = 3 m/s

nominal range of use: insulation resistance

$R_{is} \geqslant$ 5 MΩ at 20 °C
70 kΩ at 600 °C
25 kΩ at 800 °C
5 kΩ at 1 000 °C

Other influence quantities are, for example, density, viscosity, and flow velocity of the measurement medium.

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