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Principles concerning choice, official recognition, use and conservation of measurement standards

Principes concernant le choix, la reconnaissance officielle, l'utilisation et
la conservation des étalons

OIML

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 CONCERNING
CHOICE, OFFICIAL RECOGNITION, USE
and CONSERVATION of MEASUREMENT STANDARDS

0. Introduction

The purpose of this OIML International Document is to give general advice and information concerning the choice, official recognition, use and conservation of reference and working standards, i.e. measurement standards of lower orders (secondary, tertiary, etc.) used by the national services of legal metrology and calibration centers empowered by law, and by other authorized metrological services, in fulfilling their duties.

This Document does not concern either the primary, international and national standards or the measurement standards for special uses as, for example, duplicate standards, comparison standards, etc.

In this Document the term « standard » will always mean a measurement standard in the limited sens given above.

Note: standards may, or may not, differ from ordinary measuring instruments. The standards of the lower orders often have the same form as ordinary measuring instruments; they are selected, with reference to their type or their individual characteristics, from mass-produced instruments. In these cases, the standards are distinguished from ordinary measuring instruments by their intended use: calibration or verification of ordinary instruments. Systematic application of the principles concerning their choice, official recognition, use and conservation, is therefore of particular importance.

1. Application of principles

1.1. The principles concerning the choice, official recognition, use and conservation of standards are applied taking into account:
— the metrological level of the standard,
— the technical level, the complexity and size of the standard,
— the type of the standard (reference standard, working standard, standard used for calibration, standard used for verification, etc.),
— the importance of the standard for the development of science and technology, for satisfying the needs of industry and other fields of the national economy or for other interests of national importance,
— other specific cases of use.

1.2. The forms of application of these principles differ, in conformity with national regulations, depending on the organization involved :
— legal metrology bodies,
— officially delegated institutions,
— other users of standards, in industry, transport, communication, trade, etc.

The differences among those concerned are related to the competence, rights and duties of the users of standards.

1.3. The law and the decrees stipulate only the more important principles concerning the choice, official recognition, use and conservation of standards within a country. The other principles, as well as the specific requirements for different types of standards, are defined by the metrological regulations.

The most specific form of application of these principles is represented by the provisions concerning the use and conservation of a given set of standards or of a given individual standard. These provisions may be in the form of one complete document or a set of references: references to the law, decrees, metrological regulations, technical norms, etc. The manuals published by the manufacturer, safety requirements, etc. may also be included.

2. Choice of standards

2.1. In choosing a standard, the metrological, technical and economic aspects must be considered.

The metrological aspects concern:
— the basic and other metrological characteristics of the standard (point 2.2),
— the methods used for comparing a measuring instrument to be calibrated or verified with the standard as well as the methods for the calibration or the verification of the standard itself,
— the evaluation of the results of measurements made using the standard.

The technical aspects concern:
— the ease of use of the standard, its simplicity and reliability,
— the ease of transport, of dismantling and reassembly, of installation, of connection with and fitting in a calibration or verification device,
— the means of protection, against damage, pollution and interference, etc. during use and conservation of the standard,
— the special accessories required during use and conservation of the standard (installation, reading, recording, electric power supply, etc.).

The economic aspects concern:
— the cost of the standard and of its accessories,
— the cost of operation, maintainahce and conservation,
— the possibility for repair and the service life,
— the utilization,
— the space required for its use,
— the number and qualifications of the staff required.

Note: the choice of a standard may be considered to be a search for an optimum solution taking into account the restrictions imposed by the prescribed metrological characteristics. In practice however, there are other additional restricting factors, for example:
— the task of standardization of equipment,
— the lack of regulations (national or international) for certain patterns of standards,
— the tendency to automate the measurements and calculations,
— the effect of traditions, etc.

These factors, for the most part, have an overall effect (technical, economic but also metrological) and are likely to reduce the choice considerably.

2.2. The basic metrological characteristics of a standard are as follows:
— accuracy,
— stability,
— metrological reliability.

Note: the metrological reliability is the ability of a standard to fulfill its intended function while maintaining the required accuracy for a predetermined period and under defined conditions.

In addition to these generally required basic characteristics other metrological characteristics may, in some cases, be important, for example:
— measuring range or total or partial nominal value, in the case of a material measure,
— reference conditions,
— load, in the case of a meter,
— reading certainty,
— sensitivity,
— linearity or maximum permissible hysteresis error,
— dynamic metrological characteristics, etc.

2.3. The accuracy of a standard is determined by:
— either a comparison with a reference standard of a higher order of the same quantity,
— or an evaluation of its errors by using methods and measurement means (for example, standards of other quantities, calibration devices, etc.) which allow to maintain the compatibility of the standard with national standards and with officially recognized methods (traceability).

The determination of the accuracy of a standard includes the evaluation of:
— either the total systematic errors (bias errors) and the random errors (repeatability errors) of the standard,
— or the total error, i.e. the inaccuracy of the standard.

In specific cases, where any component of inaccuracy is evidently negligible, the regulations may allow the simplification of the test limiting it to the evaluation of the predominant (systematic or random) errors only. Regulations may prescribe when and how the errors of the reference standard are to be taken into consideration.

2.4. The accuracy tests of a standard may, depending on the case, result in :
— the attribution of conventional true values to the indicated values by means of a table, a calibration curve or an equation,
— the attribution of intrinsic errors (and sometimes of complementary errors) to the indicated values, by means of a table, an error curve or an equation [*],
— the determination of gauging errors of the material measures,
— the determination of maximum permissible errors of the standard over the nominal range of its use,
— the attribution to the standard of an order of accuracy usually based on the determination of its maximum permissible errors, (limits of errors or uncertainties of measurements) over the nominal range of its use.

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[*] Sometimes, instead of errors corrections are used equal to the values of the errors with opposite sign.

The accuracy tests are carried out on each individual measuring instrument likely to become a standard, and are repeated within periods either prescribed by regulations or specified in the calibration certificate.

Note: for further details concerning the choice, definition and determination of metrological characteristics relating to the accuracy of measuring instruments, see the International Documents being prepared by the OIML Secretariat SP21.

2.5. The stability and metrological reliability of a standard are assessed by:
— the study and examination of the principle of operation, the design and the construction of the standard,
— the evaluation of the materials used in construction, the method of manufacture and assembly of the standard,
— the experience gained in long-term testing of specimens of the standard,
— the evaluation of records (control cards, etc.) of detailed information concerning the standard.

In view of the high professional qualifications of the staff and the long duration of the tests required for a full assessement, as indicated above, regulations often limit the choice of the measuring instruments as standards to well-known types and categories of instruments.

2.6. The stability or metrological reliability tests allow to determine whether a measuring instrument of a certain design, pattern or manufacture may be considered as a standard for a given application and to fix the periods between calibrations and verifications.

3. Official recognition of standards

3.1. Satisfactory metrological characteristics, determined in a prescribed manner, are the conditions necessary for the official recognition of a measuring instrument as a standard.

3.2. The official recognition of standards may take, according to national regulations and practice, various forms, in particular:
— verification i.e. testing and either apposition of marks or issue of a verification certificate (point 3.4),
— calibration and issue of a calibration certificate (point 3.5).

This official recognition of a standard may have, from the point of view of the field of application, the following character:
— general,
— restricted,
— specified.

3.3. In order to obtain official recognition as a standard, a measuring instrument shall comply, according to point 3.1, with the following requirements:
— the pattern of the instrument shall have the required stability and metrological reliability,
— all modifications to the construction of the instrument shall be taken into consideration in accordance with the regulations in force and the requirements of pattern approval,
— at the time of testing, the instrument shall comply with the accuracy requirements for the standard,

— during testing, the national and international regulations and recommendations concerning the hierarchy scheme (traceability), the measurement procedures and the evaluation of the measurement results shall be respected,

— the tests shall be carried out by authorised persons using the means and devices officially recognised or complying with the regulations in force.

3.4. The verification of standards is carried out by competent bodies according to principles similar to those for verification of ordinary measuring instruments subject to mandatory verification, namely:

— only the standards of approved pattern are verified,

— the conditions, extent and method of testing are specified by the regulations in force,

— the tests are followed by either the application of verification marks or the issue of a certificate; however, in the case of standards as opposed to ordinary instruments the use of verification marks is reduced to the very minimum, often only to the identification marks, and the issue of verification certificates is recommended.

3.5. The calibration (followed by the issue of a calibration certificate) is carried out by the competent bodies designated by regulation or having authority delegated for this purpose. Calibration is not linked with pattern approval. The conditions, the extent and procedure of testing are often regulated only by general prescriptions and requirements concerning the metrological characteristics and are not specified in so strict and detailed manner as for verification. This requires however more skill and a higher level of responsibility.

Note: the traceability of a standard should have some relevance to the way the standard is going to be used. In other words, the characteristics of a standard (accuracy, etc.) must bear some relation to its method of use.

4. Use of standards

4.1. The principles concerning the use of standards aim to ensure, whenever possible and within defined limits, that the following are avoided:

— malfunction of the standard, or of the calibration system, owing to interaction between the standard and the measuring instrument being calibrated or verified, or to any other external effects,

— incorrect results of calibration or verification,

— damage, of any kind, to the standard, the measuring instrument being calibrated or verified or the testing device,

— danger to persons using the standard,

— unacceptable levels of pollution of the environment (noise, vibration, radiation, chemical products, etc.) resulting from the standard itself or its use,

— use of the standard for purposes other than those for which it is intended.

In addition, these principles may contribute to:
— increased efficiency of testing and associated operations,
— greater economy in the use of energy and materials,
— longer life of the standard and of the calibration or verification device, etc.

4.2. The principles concerning the use of standards may be given, grouped and applied in different ways. According to their nature they may be classified as follows:

— general principles, valid for all standards,

— specific rules, valid for standards of a certain type and for a certain quantity,

— individual provisions, valid for standards of a certain pattern, manufacture and defined method of use.

The application of these principles may be mandatory, recommended or optional (according to regulations). At the same time, their application may vary according to the quantities, the types of measuring instrument or depending upon the users of the standards (for example, special requirements concerning the use of standards are in force in verification offices).

Note: in the absence of particular metrological regulations or if these are inadequate, the requirements in points 4.3, 4.4 and 4.5 may be taken as the basis for specific provisions to be applied in the use of a standard.

4.3. The general principles concerning the use of standards are as follows:

— the use of the standards, referred to in this document, shall be restricted to the calibration and verification of standards of lower order, within a prescribed hierarchy, and of ordinary measuring instruments. These standards shall not be used for ordinary measurements,

— the use of the standards shall be restricted to qualified and authorised personnel. When several persons are using the same standard, one person may be designated as responsible for the standard,

— as a rule standards, except those intended as travelling standards, shall be used in a given location and environment, and with specified devices and measurement procedures,

— the user shall regularly check the condition of the standard and, after expiry of the validity of the certificate, present it for recalibration or reverification,

— when damaged in use, due to wear and tear, or when there is doubt about its correctness, the standard shall not be used and shall be submitted for recalibration or reverification, or be withdrawn,

— records shall be kept of the use and controls of the standard,

— the use of the standard shall agree with the corresponding hierarchy and comply with the specifications which fix the ratio between the accuracy of the standard and that of the standard of lower order or of the measuring instrument being calibrated or verified.

4.4. The specific rules concerning the use of standards of a certain type are contained, in general, in the metrological requirements relating to their calibration and verification or to their use for the calibration and verification of measuring instruments. They determine, in particular:

— the accessories of the standard and its documentation,

— the requirements concerning the place of use,

— the installation, adjustment and preparation of the standard for use,

— the measurement procedures, the permitted or prohibited operations,

— the method of recording and of evaluating the measurement results,

— the external examinations, the functional and metrological controls,

— the safety precautions to be taken when working with the standard, the measures to be taken to prevent any significant level of pollution of the environment.

4.5. The individual provisions concerning the use of a given standard, under given conditions, contain all the necessary information for the user, resulting from the principles and regulations, but also the specific conditions concerning the use of the standard, the environment, etc. The individual provisions concerning the use of the standard form part of its documentation and provide the necessary basis for the information, documentation and legal protection of its use.

5. Conservation of standards

5.1. The principles concerning the conservation of standards aim to ensure that storage, maintenance, transport and conservation of standards are carried out by qualified personnel, under the correct conditions and at the correct times. Their application, during the above-mentioned operations, allows to avoid:
— damage to the standard,
— loss of the characteristics of the standard,
— loss of the standard or of its accessories,
— danger to the safety of personnel and pollution of the environment.

5.2. The classification of the principles concerning the conservation of standards is the same as that which applies to the principles concerning their use (point 4.2.).

5.3. The general principles concerning the conservation of standards are as follows:
— the standard, when not in use, is kept in a specified place,
— one or more persons responsible for the conservation of the standard are appointed, (usually the same person(s) is(are) also responsible for its use),
— storage, maintenance, transport and conservation of standards are carried out according to recognised methods and procedures, or according to special provisions,
— the conservation of standards includes the documentation concerning them,
— periodic checks of the condition of the standards are carried out.

Note: repairs are not part of the conservation of standards; these are controlled by special principles and regulations.

5.4. The individual provisions concerning the conservation of a given standard comprise all the information required by a person in charge of it; they result from the general principles of the regulations in force and from other recognized methods and procedures (recommendations of international and national metrology laboratories, manufacturers recommendations, etc.). The individual provisions concerning the conservation of a standard form part of its documentation. In addition to their documentation and information function these provisions provide the necessary legal basis for the conservation of the standard and for the legal protection of the person in charge of it.

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